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Inner music—hearing music inside your head that isn't playing in the environment—is a common experience that takes many forms. Research on inner music, however, has primarily emphasized instances of involuntary, aversive musical imagery, such as "earworms." The present research develops a new conceptual framework, consisting of five fundamental dimensions, that can advance our understanding of inner music. In an experience-sampling study, a sample of musicians and people from the general university community (N = 132) was recruited to examine inner music as it occurs in-the-moment in everyday life. Over the course of a week, participants were contacted throughout the day and asked about their experiences with inner music, with an emphasis on the five dimensions: Affective Valence, Repetitiveness, Vividness, Mental Control, and Length. The results showed that there is variability at both the within-person and between-person levels on each of the proposed dimensions—people have a variety of musical imagery experiences, not just a few different types. Additionally, these dimensions were related to three different individual difference factors: personality, musical expertise, and auditory imagery ability. Openness to experience and extraversion, musical training, and the ability to form vivid auditory images were the primary predictors of the qualities of inner music. Additionally, the present research has implications for how musical imagery is measured—retrospective and in-the-moment reports differed considerably, suggesting people cannot accurately recall their inner music experiences. Overall, the findings show considerable variability in musical

imagery and that focusing on specific types of inner music (e.g., earworms) ignores many other experiences. Looking at the qualities of inner music will be fruitful for future work and broaden the scope of research.

UNDERSTANDING INNER MUSIC:
A DIMENSIONAL APPROACH
TO MUSICAL IMAGERY

by

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CHAPTER I

INTRODUCTION

We all hear music in our minds. Inner music—internal musical imagery that isn't playing in the environment—is a fascinating example of people's deep engagement with music, and recent years have seen a rapidly growing literature devoted to understanding it. Initially, research sought to describe the typical experience of inner music as it occurs in the general population (e.g., Beaman & Williams, 2010; Liikkanen, 2008, 2011). Since then, the literature has developed an overly narrow view of musical imagery, one that emphasizes the most salient examples. One such example is the earworm—the unpleasant experience of a song popping into your head and repeating. The emphasis on earworms obscures forms of musical imagery that are less common but theoretically interesting.

In the present research, I suggest a new model to capture the variety of inner music experiences. In this model, I identify five dimensions of inner music: Affective Valence, Repetitiveness, Vividness, Mental Control, and Length. Taking a dimensional approach highlights the complexity and variability of musical imagery, and it allows for studying this variability in each continuous dimension instead of focusing on a singular type of experience. In the present research, I test this model using experience sampling methods (ESM) and demonstrate the complexity and breadth of inner music experiences.

One focus of this project is to explore the role mental control plays in differing experiences of inner music. Research thus far has typically assumed that inner music is

something that begins without your control, but this is not always the case. There are instances when people consciously decide to start hearing music in their mind, such as to work on a personal composition or to alleviate boredom by tuning in to their inner radio. In assuming the involuntary nature of inner music, past work has ignored many musical imagery experiences. In addition, I examine a second, previously unstudied form of mental control in inner music: maintenance. Maintenance in musical imagery is when people decide to keep the music playing or exert other forms of control over their inner music, regardless of whether they intended for the music to begin. This aspect of mental control has yet to be mentioned in the musical imagery literature but likely is used in some inner music episodes. The distinction between initiation and maintenance is novel in this field, and I seek to substantiate the existence and use of both components during musical imagery experiences. Mental control's role in inner music has not received the attention it deserves and is an interest of the present research.

Involuntary Musical Imagery

The dominant approach to inner music emphasizes a prototype experience: music that is aversive, repetitive, intrusive, and involuntary. This prototypical experience—referred to as *earworms*, *stuck songs*, or more generally as *involuntary musical imagery* (see Williams, 2015, for a review)—is easy to relate to, as everyone has had experiences of irksome and unwanted songs playing in their heads. Nevertheless, there are two issues with this approach. First, it represents a narrow and restrictive view of inner music, one that implies that it is typically unpleasant and uncontrolled. This view of inner music, with few exceptions, is the standard model in musical imagery research—indeed,

involuntary musical imagery is now a common global term for musical imagery (Williams, 2015).

Second, it tacitly emphasizes a "type" of experience rather than the underlying dimensions of imagery that describe it. For example, earworms can be viewed through the lens of the proposed model as imagery that is involuntarily initiated, negative in valence, and repetitive, but varies in vividness and length. If we think about an "earworm" in this way, it becomes apparent that it is only one of the many kinds of imagery contained within the conceptual space created in a five-dimensional model, including forms that are controlled or positive.

Most research takes an "earworm" typology approach. The majority of researchers ask participants to report on their earworms (Floridou & Müllensiefen, 2015; Halpern & Bartlett, 2011) or songs that are stuck in their head, with descriptions mirroring commonly used definitions of earworms (Beaman & Williams, 2010, 2013; Hyman et al., 2015). In addition, the only inner music scale developed is entitled "The Involuntary Musical Imagery Scale" (IMIS; Floridou, Williamson, Stewart, & Müllensiefen, 2015), and it asks participants to rate qualities of their earworms. Even in research that does not explicitly use terms such as *involuntary musical imagery* or *earworms*, the questions reflect the narrow conceptualization of inner music that restricts it to involuntary forms (e.g., Liikkanen, 2008, 2011). Notably, a few researchers do not use this language (e.g., Bailes, 2006, 2007, 2015; Beaty et al., 2013) and have suggested that it is needlessly limiting (Bailes, 2015).

The problem with the earworm tradition is that the evidence to date does not support elevating earworms to the most common, prototype case. For example, the hallmark trait of an involuntary musical earworm is that it is an aversive, negative experience. Though there has been some research documenting negative experiences under specific circumstances (e.g., Beaman & Williams, 2013; Floridou & Müllensiefen, 2015), people commonly report finding inner music to be a pleasant experience (Beaman & Williams, 2010; Beaty et al., 2013; Floridou & Müllensiefen, 2015; Halpern & Bartlett, 2011; Hyman et al., 2015). Additionally, in her ESM study Bailes (2007) found that people rarely considered their inner music to be irritating. Likewise, researchers have assumed that inner music is intrusive and involuntary, but the evidence is surprisingly thin. Because most research has assumed the intrusive and involuntary nature of inner music, there has yet to be research examining how often, and when, musical imagery is actually involuntary versus controlled. Beaty and colleagues (2013) found that some participants reported their inner music to be something they were composing or improvising. Though they did not explicitly ask about mental control, the nature of composition and improvisation implies that people were exerting control over their inner music. Furthermore, a third component of involuntary musical imagery is its repetitiveness. This component does have more empirical support (e.g., Bailes, 2007, 2015; Liikkanen, 2011), but not all inner music is repetitive (Bailes, 2007). Research has largely ignored mental rehearsal and mental composition—prime examples of non-repetitive musical imagery—so the full breadth of these experiences has yet to be explored.

If we contrast the field of inner music with that of a more widely studied type of mental imagery—visual imagery—the weaknesses of the involuntary musical imagery prototype become evident. Visual imagery has identified a number of broad dimensions that describe inner visual experiences, such as vividness, control, and preference (see McAvinue & Robertson, 2006-2007 for review). Vividness, by far the most studied quality of visual imagery, has a host measures dedicated to the investigation of this single dimension of visual imagery (e.g., Marks, 1973; Sheehan, 1967). Control, though less widely studied, also has measures evaluating this aspect of visual imagery (e.g., Gordon, 1949). More recent work has developed visual imagery preferences, such as the tendency to utilize object imagery—the ability to generate images of people or objects—or spatial imagery—the ability to generate mental images of spatial relationships or movements (Blazhenkova, 2016). Though not an exhaustive review, these examples demonstrate there are related, but separate, components of visual imagery that vary rather than discrete types of mental images. Additionally, the large literature on visuospatial abilities (see Carroll, 1993 for review) demonstrates that researchers recognize the role mental control can play in visual imagery, something musical imagery research has overlooked thus far.

A Dimensional Model of Inner Music

Research on inner music, by focusing on a specific type of experience, is inadvertently narrowing its scope. If the field of inner music is to become broader and grow, there first needs to be a change of terminology. The current default label of *involuntary musical imagery* represents a subset of musical imagery experiences, and its

use should be confined only to that subset of experience. Instead, I propose using *musical imagery* or *inner music*. Like *visual imagery*, inner music and musical imagery represent a broad range of experiences. These terms also allow for specific types of inner music (e.g., involuntary musical imagery, deliberate rehearsal, earworms, hallucinations, mental improvisation) to be examined while still emphasizing parallels between seemingly diverse experiences.

A second lesson taken from visual imagery is the use of dimensions in defining different aspects of a singular experience. Some research has tried to identify themes associated with inner music (Williamson & Jilka, 2014; Williamson et al., 2011), and a dimensional approach can highlight conceptual similarities between the range of inner music experiences. Thus, I propose a five-dimension model through which inner music can be studied: Affective Valence, Repetitiveness, Vividness, Mental Control, and Length.

Affective valence. The *Affective Valence* dimension reflects how someone feels about the music that is playing in their mind, not the emotions expressed in the music. Specifically, it involves whether having music in one's mind is pleasant and wanted versus irritating, distressing, or unwanted. By nature, this dimension is metacognitive since people are evaluating their mental states. Typically, this dimension is measured by how positively or negatively inner music is viewed, and has been phrased as how pleasant (Beaman & Williams, 2010; Floridou & Müllensiefen, 2015; Halpern & Bartlett, 2011), positive (Williamson & Jilka, 2014), liked (Beaty et al., 2013; Hyman et al., 2015), irritating (Bailes, 2007), pesky (Liikkanen, 2011), and negative (Floridou et al.,

2015) musical imagery is. Research has shown the existence of the irksome earworm but also demonstrated the strikingly high prevalence of pleasant inner music episodes. The emphasis researchers have placed on the subjective valence of inner music experiences clearly demonstrates its importance as a dimension.

Repetitiveness. *Repetitiveness* addresses whether the music plays as a recurring loop or as an extended auditory image. Liikkanen (2011) found that while half of respondents did report their inner music to be repetitive, over one-third reported experiencing non-repetitive inner music. Other research has also found reports of both repetitive and non-repetitive inner music (Bailes, 2007, 2015; Halpern & Bartlett, 2011). People with musically-oriented goals may be more likely to have non-repetitive inner music—in cases such as mental rehearsal, composition, or improvisation it is unlikely that the inner music will be repetitive. As previous research tended to assume inner music was repetitive, it is important to consider this aspect of musical imagery to be its own dimension.

Vividness. *Vividness* is a widely studied component of mental imagery. For the purposes of inner music, vividness can be broken down into three facets: realism, complexity, and multi-modality. Realism, how lifelike mental imagery is, is vividness in its traditional sense. Research shows that people report their inner music experiences as being similar to actually listening to the song (Hyman et al., 2015); however, there is undoubtedly variation in how lifelike an inner music episode will be and variation as a function of individual differences, such as musical expertise. Additionally, the complexity of inner music should be considered: Are only a few instruments playing or is

it the full accompaniment? Is only the melody heard or are harmonies present? For lyrical music, is it only a voice, or is there backing music? Some research has found that the melody, tempo (Bailes, 2015), and lyrics (Bailes, 2007) were the most vivid aspects of inner music among music students, and the lyrics, melody, and singer's voice were the most common components of music present (Hyman et al., 2015). Finally, musical imagery can be multimodal. When people are listening to music, there are often physical movements that accompany the experience (e.g., tapping your foot, practicing finger movements for playing an instrument). Similarly, these movements can occur when hearing inner music. In theory, with increased vividness, there would be a higher likelihood that these types of movements will occur. Though it has not been widely studied with musical imagery, vividness's centrality in the broader field of mental imagery necessitates its inclusion as a dimension of inner music experience.

Mental control. Past work has almost exclusively considered musical imagery to be involuntary, but there are several ways in which inner music can be voluntary. Drawing on the broader literatures on executive control and visual imagery, I propose two aspects of control over musical imagery: *Initiation* and *Maintenance.* Inner music can vary in whether people deliberately initiated it (e.g., as in mental rehearsal, composition, or entertainment) or not (e.g., imagery sparked from recently hearing a familiar song on the radio). Initiation is the sense of "involuntary" that is presumed by most research using the label *involuntary musical imagery*. The broader psychology of music offers many examples of voluntary initiation of inner music. Typically, these studies have focused on musicians and the ways they use inner music to enhance their

performances. Musicians deliberately use inner music in preparation for upcoming performances (Bailes, 2006; Gregg, Clark, & Hall, 2008) as well as during their performances through anticipating upcoming musical lines (Keller, 2012; Saintilan, 2015). Inner music is also important in musical composition (Bailes, 2007, 2015; Beaty et al., 2013). Initiation, however, has not been examined in non-musician samples. It is likely that non-musicians do initiate inner music, although the motives for initiation might vary.

Likewise, inner music can vary in whether people deliberately keep it going. Imagery initiated involuntarily may nevertheless be maintained deliberately, such as when people want to keep listening to a familiar song or to purposefully develop a musical fragment into a full composition. Similarly, people could manipulate the imagery after it has begun, such as skipping ahead; altering the lyrics, key, or tempo; or improvising based on the original image. Though it has not been examined through the lens of control, research has found that people often want their inner music to continue playing (Bailes, 2007). Most research, however, has not asked questions that would assess the maintenance aspect of mental control.

A similar distinction has recently been made in the related field of mind wandering (see Seli, Risko, Smilek, & Schacter, 2016 for review). Similar to musical imagery research, the mind wandering literature assumed it to be an involuntary, unintentional phenomenon but Seli et al. (2016) suggest that this assumption may not be accurate and that intentional, controlled forms of mind wandering do exist. Furthering this distinction, they also state that intentional mind wandering can occur in two ways—

through the willful *initiation* of mind wandering or by choosing to continue the mind-wandering episode (i.e., *maintenance*). The field of inner music is in a similar state by assuming its involuntary nature, and the next step is to investigate controlled forms of musical imagery. In short, it is clear that viewing all inner music as involuntary misses much, and that control over musical imagery is multifaceted.

Length. Musical imagery varies in its length. Length has two facets: the duration of the whole musical imagery experience, and the length of the section of music playing in the mind. Most research has focused on the length of the entire inner music episode. People report their inner music lasting only seconds (Halpern & Bartlett, 2011), for hours (Beaman & Williams, 2010; Halpern & Bartlett, 2011), for several days (Halpern & Bartlett, 2011), or always present, something that has been termed a "perpetual music track" (Brown, 2006). Clearly, there is considerable variability in how long episodes of musical imagery last.

There is less information, however, about how long *sections* of music within an episode are. Though people report hearing portions of songs or songs in their entirety (Liikkanen, 2011) indicating some degree of variation, research has not focused on how long sections of inner music tend to be. The recently developed IMIS (Floridou et al., 2015) does include an item about the length of musical sections, and my recent work shows that people do report variation in section length (Cotter, Christensen, & Silvia, 2016). Therefore, it is important to examine variation in the length of both episodes and sections in musical imagery experiences.

The Present Research

To examine this model of inner music, I used ESM. Most research has used cross-sectional designs that ask people to retrospectively reflect on and describe their typical inner music experiences (Beaman & Williams, 2013; Halpern & Bartlett, 2011; Hyman et al., 2015; Liikkanen, 2011). It is unclear how well people encode and recall transient imagery experiences, so surveys that require retrospection or that ask about typical experiences are likely to be inaccurate. ESM is unique, however, because it allows participants to report their inner experiences as they happen. A small literature has applied ESM to inner music and shown that it is feasible (e.g., Beaty et al., 2013), but most ESM studies to date have either generally defined inner music to participants as unpleasant earworms or as involuntary (Byron & Fowles, 2015; Floridou & Müllensiefen, 2015), or they have used small, narrow samples (e.g., 11 music students; Bailes, 2006, 2007).

The present research had a sample with a wide range of music expertise. I recruited music majors with various concentrations (e.g., performance, education, theory), as they may be more likely to use musical imagery due to their specialized musical goals. Oversampling different types of musicians will serve to broaden the sample and aid in capturing a wide range of inner music experiences. Though people report experiencing inner music frequently (Liikkanen, 2011), it is likely that musicians will have more salient musical motives that may influence the frequency and content of their inner music. For example, a pianist with an upcoming recital may be more likely to

use controlled forms of inner music, such as mental rehearsal, to improve her performance.

ESM studies have two levels of assessment. At Level 1, the within-person level, people reported their in-the-moment experiences. Participants were first asked if they were experiencing inner music and, if so, additional questions about the qualities of their inner music that reflect the five proposed dimensions. Additionally, everyone reported their mood and their environment at the time of survey completion. Collection of these within-person variables at several time-points throughout the day for seven days permits me to examine how the dimensions of inner music differ as a function of mood, environmental factors, and combinations of other inner music qualities.

At Level 2, the between-person level, participants completed a battery of individual difference measures, including personality, retrospective reports of inner music, musical expertise, and auditory imagery abilities. Unsurprisingly, several studies have examined how musical expertise relates to inner music. Typically, musical expertise has been categorized by being a music major in college (Bailes, 2006, 2007; Beaty et al., 2013; Clark & Williamon, 2011) or having musical training (Liikkanen, 2011). Generally, music experts more frequently experience episodes of inner music (Bailes, 2006, 2007; Beaty et al., 2013) and report using musical imagery when preparing for performance (Bailes, 2006) and even during their performances (Saintilan, 2015). This method of determining musical expertise, however, typically results in musician versus non-musician groupings. My approach considered musical expertise as a continuous rather than a binary variable. I still expect to find differences in the reported experiences

of inner music based upon musical expertise, primarily in the form it takes (i.e., more instances of controlled imagery in musical experts).

As personality is one of the most widely studied individual differences, I included a measure of the five factor model of personality and its facets. Openness to experience is strongly associated with the arts, imagination, and creativity (Kaufman, 2013; Kaufman et al., 2015), so it follows that openness would also be strongly related to internal representations of the arts. Prior musical imagery work supports this—openness has been related to both the frequency of musical imagery (Beaty et al., 2013; Cotter, Christensen, & Silvia, 2016) and qualities of the musical imagery experience (e.g., length of episodes; Cotter et al., 2016; Floridou, Williamson, & Müllensiefen, 2012). Neuroticism has also been related to the frequency (Beaty et al., 2013; Kellaris, 2001) and qualities of the inner music experience (Cotter et al., 2016; Floridou et al., 2012), but these relationships were notably smaller than those with openness.

To explore the accuracy of retrospective imagery reports, I administered a newly developed scale: the IMIS (Floridou et al., 2015). Though recent work (Cotter et al., 2016) found the expected relationships between openness to experience and neuroticism and the frequency of inner music on the IMIS, they were notably smaller than those found in ESM research (e.g., Beaty et al., 2013). Additionally, this scale uses "earworms" as its descriptor of inner music and the proposed research does not, so it is likely that the everyday experiences will not closely match the reports given on the IMIS. Thus, the present research will serve as a test of the ecological validity of this new scale.

I also explored whether general auditory abilities relate to experiences of inner music using the newly developed Bucknell Auditory Imagery Scale (BAIS; Halpern, 2015). Previous research has yet to examine the relationship between auditory imagery ability and musical imagery, so inclusion of this measure is for exploratory purposes. The BAIS is a unique measure as it includes a subscale concerning imagery control in addition to the traditionally studied dimension of vividness. As inclusion of this scale is exploratory, I am not formulating specific hypotheses. It may be the case that people who can control their auditory imagery exert more control over their inner music in daily life. At the same time, just because people can use mental control easily does not mean they will choose to do so.

Given the literature's narrow focus and limited use of ESM in the study of inner music, the present research is an innovative addition to the field. Given my focus on the five proposed dimensions of musical imagery, the information provided by the descriptive statistics and within-person relationships are a major contribution of this work. To demonstrate that a dimensional approach to inner music is appropriate, musical imagery episodes must vary on each of these dimensions—this will be assessed through basic descriptive statistics. Additionally, I also examine how musical imagery relates to several individual differences. My predictions concern the frequency with which different qualities of inner music occur (e.g., controlled versus uncontrolled) and how key factors (e.g., musical expertise) predict the frequency and qualities of inner music. I anticipate large differences between musical experts and musical novices in their experiences and uses of inner music. I expect that musical experts will report more instances of inner

music and indicate more frequent use of mental control, both by initiating and maintaining their inner music. ESM projects yield an enormous amount of data, so I also conducted additional analyses that consider the roles of normal personality traits (e.g., Openness to Experience) and contextual factors (e.g., ongoing mood states) in inner music experiences.

CHAPTER II

METHOD

Participants

Participants were 150 students who volunteered as part of a class research participation option (n = 128) or responded to a flyer asking for music major participants for psychology research (n = 22). Eighteen participants were excluded from analyses due to elevated scores on items capturing inattention (see Maniaci & Rogge, 2014; McKibben & Silvia, in press, 2016) or for completing fewer than 5 ESM surveys, a recommended minimum for daily life research (Bolger & Laurenceau, 2013). This resulted in a final sample of 132 (110 research volunteers; 22 music majors). Overall, the sample was young (M age = 19.90, SD = 4.60, range 18-53), predominantly female (n = 102, 68%), and racially diverse (49% European American and 42% African-American). Participants were compensated with research credits or $20 for participation.

Between-Person Measures

Goldsmiths Musical Sophistication Index (Appendix C; Müllensiefen, Gingras, Musil, & Stewart, 2014). This scale, unlike other musical expertise measures (e.g., Ollen, 2006), is designed to consider multiple factors of expertise beyond formal musical training, which allows it to differentiate a broad range of abilities instead of distinguishing only between musicians and non-musicians. *Active Engagement*, the first factor, quantifies the amount of time and effort people put into interacting with music

(e.g., reading or writingabout music, openness to new music; 9 items). *Perceptual Abilities*, the second factor, examines whether people are able to judge musical experiences (e.g., picking out mistakes, identifying genres, recognizing familiar songs; 9 items). The *Singing Abilities* factor (7 items) asks participants to reflect on their personal singing ability, such as being able to sing along to songs accurately or sing a song from memory. A fourth factor, *Emotions* (6 items), assesses the emotional reactions participants have to music and their ability to communicate these emotions. Additionally, *Musical Training* (7 items) is its own factor. It assesses participants' formal training in music and their identity as a musician. The scale also yields a composite *General Sophistication* score that is composed of items from each of the sub-factors (18 items). These items are rated on a scale from 1 (*Completely Disagree*) to 7 (*Completely Agree*).

Bucknell Auditory Imagery Scale (Appendix D; Halpern, 2015). This measure examines two components of auditory imagery: *Vividness* and *Control*. In both subscales, there are three types of auditory experiences participants are asked to imagine—music, environmental sound, and voice—to examine auditory imagery ability across a variety of situations. In the 14-item *Vividness* subscale, participants are presented with a general situation (e.g., the beginning of "Happy Birthday") and then instructed to imagine a specific auditory experience associated with the provided situation (e.g., a trumpet playing the beginning of the song). Once participants have the mental image formed, they rate the vividness of their mental image from 1 (*No Image Present at All*) to 7 (*As Vivid as the Actual Sound*).

In the 14-item *Control* subscale, participants are again presented with a general situation and instructed to imagine a specific auditory experience. Once participants have this initial image in mind, they then receive a modification to their original mental image (e.g., the trumpet stopping and a violin playing the song instead). After the participants have formed the modified mental image, they rate how easily they were able to move from the initial to the modified auditory image on a scale from 1 (*No Image Present at All*) to 7 (*Extremely Easy to Change the Image*).

Involuntary Musical Imagery Scale (Appendix E; Floridou et al., 2015). This 18-item scale measures the subjective experiences of "earworms"—defined by the scale as "the experience of a short section of music that comes into the mind without effort and then repeats" (p. 29)—on four factors: negative valence (e.g., *I find my earworms irritating*), movement (e.g., *The way I move is in sync with my earworms*), personal reflections (e.g., *Personal issues trigger my earworms*), and help (e.g., *I find my earworms help me focus on the task that I'm doing*). Items are rated on a scale from 1 (*Always*) to 5 (*Never*). For interpretation purposes, the subscale scores were reversed, in that higher scores indicated higher levels of the quality. For the present research, I focused on the *Negative Valence, Movement,* and *Help* subscales.[1] This scale also measures the frequency of earworm episodes (*Never; Once a month; Once a week; Several times a week; Several times a day; Almost continuously),* how long each episode

[1] I chose not evaluate the *Personal Reflections* subscale because it primarily addresses what triggered the episode of musical imagery. Previous studies have found that the most common triggers are hearing the song recently (Bailes, 2007, 2015), and preparing for a performance (Bailes, 2007), or not knowing the trigger (Bailes, 2007, 2015).

tends to last (*Less than 10 minutes; Between 10 minutes and half an hour; Between half an hour and 1 hour; Between 1 and 3 hours; More than 3 hours)*, and how long the section of repetitive music is (*Less than 5 seconds; Between 5 and 10 seconds; Between 10 and 30 seconds; Between 30 seconds and 1 minute; More than 1 minute)*. Participants were asked to think about their experiences of earworms and to rate the characteristics of a typical earworm rather than one specific earworm.

NEO-PI-3 (McCrae & Costa, 2010). This 240-item inventory measures five domains of personality: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. All items were on a scale from 1 (*Strongly Agree*) to 5 (*Strongly Disagree*). Given their past association with inner music, I also examined the facets of openness to experience (fantasy, aesthetics, feelings, actions, ideas, and values) and neuroticism (anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability).

Experience Sampling Surveys

Musical imagery survey (Appendix F)**.** Multiple times a day during the data collection period, participants filled out a 29 item survey. People were first asked whether or not they were experiencing inner music. Participants who reported inner music were directed to questions about the five proposed dimensions of inner music: *Affective Valence* (2 items); *Repetitiveness* (1 item); *Vividness* (3 items); *Mental Control* (5 items); and *Length* (2 items). There were also four additional items asking whether the inner music was something they were rehearsing, composing, or improvising; if the music is

distracting them; and if they are paying attention[2] to their inner music. If they indicated they were not experiencing inner music, they were filtered to a branch of filler items about the quality of their thoughts that was as long as the inner music questionnaire. After filling out the inner music or filler items, everyone answered questions about their current feelings and mood and the environment they were in when signaled.

Start-of-day sleep survey (Appendix G)**.** Each morning during the data collection period, participants completed a three question survey. These items asked participants to report when they woke up that morning, how long they slept the previous night, and the quality of their sleep.

Experience-sampling apparatus. MetricWire is a smartphone application designed for mobile data collection. The experience sampling surveys were programmed into MetricWire, and participants received a notification when there was a new survey available for them to complete. The start-of-day survey was available beginning at 7:15 a.m. and remained available until it was completed each day. After a notification for the experience sampling survey appeared, participants were given a 5-minute window to begin the survey before it closed; MetricWire sent a reminder notification after 30 seconds if the survey had not yet been opened. Each experience sampling survey appeared at quasi-random times at least 40 minutes apart between 8 a.m. and midnight.

[2] Only the item asking if the music is distracting was used in the present analyses to compare the similarity in the measurement of inner music using ESM and retrospective measures. As the three remaining items were not part of the dimensional structure, they are not considered further.

MetricWire allows researchers to track the completion of surveys in real time, which allowed us to selectively contact participants with poor response rates to address any potential technical malfunctions with the application or their device. Additionally, participants were able to view how many surveys they have completed in the MetricWire application, allowing them to track their progress and whether they are eligible for entry into the raffle.

Procedure

Participants first came into the lab in small groups to begin the study. I then helped participants registered their smartphones with MetricWire and complete a practice survey. If participants did not have a smartphone or did not wish to use their personal device for the surveys, they were provided with a lab-owned 7" Android tablet with MetricWire downloaded for the duration of the study. After completing the practice survey, participants completed the individual differences measures on Medialab.

The ESM data collection occurred over 7 days. People were signaled at quasi-random times to take a survey roughly every 45 minutes between 8 a.m. and midnight. Participants were instructed to turn off their phone volume when sleeping and to ignore survey notifications if it would be inappropriate or unsafe to complete the survey. I performed a mid-week e-mail check-in with each participant to ensure they were not experiencing any technical issues with MetricWire. People with unusually low response rates after two days were also contacted by e-mail to make sure there were no technical difficulties. Upon completion of the study, participants who were provided with a lab-owned tablet returned it to the lab and were thanked for their participation. The remainder

of participants were told they could remove the MetricWire application from their personal device and thanked for their participation. Participants who completed at least 45 experience sampling surveys were entered into a raffle for one of three $40 cash prizes—36% of the sample qualified for the raffle.

CHAPTER III

RESULTS

On average, people completed the ESM survey 33.48 times (*SD* = 17.23, *range* = 5-80). Participants completed a total of 4,403 ESM surveys—1,112 (25.26%) of these surveys captured episodes of musical imagery.

Analysis Overview

Since survey responses are nested within people, the data were analyzed using multilevel models in Mplus 7.4 using maximum likelihood estimation with robust standard errors. I first focus on just the inner music items. I start by evaluating the proposed dimensional structure by looking at the descriptive statistics and correlations for the inner music items at the within-person level (i.e., at the episode level). I also consider how the qualities of musical imagery relate to the environment in which they occur. These relationships are then examined at the between-person level.

My second set of analyses considers how the qualities of inner music relate to three individual difference factors: personality, musical expertise, and general auditory imagery ability. I first look at the relationships between musical imagery and personality at the facet level. Next, I consider the prediction ability of the Big Five personality traits by regressing the inner music qualities on the personality factors. Finally, I examine how musical expertise and auditory imagery ability relate to inner music using correlation and regression analyses.

Finally, I evaluate the similarity between reports of musical imagery when using ESM and the IMIS, a retrospective measure. Correlations and regression models are used to examine the ability of retrospective measurement to predict qualities of inner music when measured using ESM.

Within-Person Inner Music Descriptive Statistics

As my primary aim is to demonstrate the utility of a dimensional model of musical imagery, the descriptive statistics for the five dimensions are theoretically important. To make a case for a credible dimensional model of inner music, there must be variation on each of the five dimensions—a lack of variability would suggest that there were specific types of musical imagery experiences, something that would support a prototype approach. To support my dimensional approach, I first consider the variability of responses in each dimension at the within-person level. I then examine the relationships within and between the dimensions to demonstrate that, while related, the five dimensions are distinct from one another. All within-person descriptive statistics can be seen in Table 1 (above the diagonal), the distribution of responses for musical imagery items are in Figure 1, and the intraclass correlations for the musical imagery items appear in Figure 2.

Frequency. Though not one of the proposed dimensions, how often people experience musical imagery is important. Overall, people reported experiencing musical imagery about 25% of the time, suggesting that musical imagery is a relatively common experience. An informative metric for ESM data is the intraclass correlation coefficient (ICC)—this indicates what proportion of the variation in responses is due to stable

between-person factors (e.g., personality). So, a small ICC means that the majority of variability in responses is due to within-person factors that can change across the day (e.g., caffeine intake, environmental factors). Most of the variability in the frequency of musical imagery episodes was within-person (ICC = .17). This means that only 17% of the variability in having a musical imagery experience is due to between-person factors, suggesting that factors fluctuating during the day primarily influence the occurrence of inner music episodes.

Affective valence. The *Affective Valence* dimension was measured with two ESM items: "I enjoy hearing the music in my mind" and "I would rather not have music in my head right now" (reverse-scored). Both items had high within-person means (5.23 and 6.00, respectively), indicating that, on average, people viewed their musical imagery episodes favorably. This becomes more striking when examining the distribution of responses (see Figure 1, panels a and b)—only 138 of the 1,104 (12.50%) responses on the "Enjoyment" item fell below the scale midpoint of the scale, and none of the responses for the "No Music" item fell below the scale midpoint. Thus it appears that unpleasant inner music experiences are not the norm but rather are a small minority of musical imagery experiences. Similar to the frequency of musical imagery, the general enjoyment of the inner music (ICC = .33) and wanting the mental music to continue (ICC = .24) primarily varied due to factors that change over the course of the day. Though most episodes were positive, my findings do demonstrate variable responses across episodes, suggesting that affective valence does not exist as just "positive" or "negative." This variability in responses supports the proposed dimension of *Affective Valence.*

Repetitiveness. *Repetitiveness* was measured with a single item: "Is the music playing over and over in a loop?" Overall, 805 of the 1,112 episodes (72.39%) were reported to be repetitive. Although the majority of episodes featured repetitive mental music, a sizeable portion of episodes contained non-repetitive music. This contradicts the notion that there is a singular, dominant type of musical imagery experience—if this were the case, there would be a larger majority of repetitive episodes. Most of the variability in repetitiveness was due to within-person factors rather than between-person factors (ICC = .22).

Vividness. The *Vividness* dimension contained three items: "The music in my mind is lifelike," "It feels like I'm actually listening to the song," and "My body is responding to the music (feet tapping, head and body moving)." The first two items—the lifelikeness and accuracy of the mental music representation—showed that, on average, people had inner music experiences that were moderately vivid (M = 4.74 and M = 4.74 respectively). Though more episodes were reported to be vivid than not, there were still a considerable portion of episodes that were not particularly vivid (see Figure 1, panels c and d). This may be related to the larger proportion of between-person variability in how lifelike (ICC = .42) and similar to the actual song (ICC = .34) the musical imagery was. The third item captured movement in response to inner music, and though it did occur occasionally (M = 3.33), most musical imagery episodes did not evoke movement (see Figure 1, panel e), and movement largely varied with situational factors (ICC = .29). Though the findings did differ between the two more traditional vividness items and the movement item, all three yielded responses that spanned the whole response scale. Given

this variability at the episode level, *Vividness* appears to be a credible dimension of musical imagery.

Mental control. The *Mental Control* dimension is made of two components: *Initiation* and *Maintenance*. The *Initiation* component was measured by two items: "I made the music in my mind start playing on purpose" and "I intended to start hearing this music in my mind." Both items had low means (2.89 and 2.94, respectively), suggesting that, on average, people were not initiating musical imagery episodes. This is further supported by the distribution of responses (see Figure 1, panels f and g)—the majority of responses fall below the scale midpoint for both items, but it is important to note that there are instances in which people were willfully initiating musical imagery episodes. The majority of the variability in starting the music on purpose (ICC = .41) or intending to start hearing inner music (ICC = .40) was within person, but there was a sizeable amount of between-person variation in the initiation of musical imagery. Although the majority of musical imagery episodes in this sample were involuntarily initiated, both items also captured a number of episodes that were intentionally and purposely started. Taken together with the amount of within-person variability in initiation, mental control appears to qualify as a component of inner music experiences and initiation fits as one aspect of this mental control dimension.

The second component, *Maintenance*, was assessed with three items: "I could make the music in my head stop if I wanted to," "I'm trying to keep the music in my mind playing," and "I feel the music playing in my mind is under my control." Trying to keep inner music playing (M = 3.07) largely mirrored the *Initiation* items—during most

episodes, people were not intentionally keeping the music going, but there were a portion of episodes in which people deliberately maintained their imagery (see Figure 1, panel i). There also was considerable within person variability in responses (ICC = .36). The other *Maintenance* items—being able to stop the episode and feeling the music is under one's control—followed a different pattern. Though responses on both items indicated that for many episodes, people felt low levels of control over their inner music (*M*s = 3.58 and 3.77), there were a number of episodes that were controllable. The distributions for these items were not as imbalanced as those of the other mental control items (see Figure 1, panels h and j). Interestingly, for ability to stop the musical imagery (ICC = .49) and feeling the music is under one's control (ICC = .48), within-person and between-person variability was almost equal. The variability across the three *Maintenance* items supports inclusion of the mental control dimension in the proposed model as well as maintenance as an aspect of mental control in musical imagery.

Length. Both the length of the overall episode and the section of music were measured (see Figure 1, panels k and l). Most episodes (76.31%) were less than 5 minutes long, but there were a handful (5.41%) that lasted over 30 minutes. Similarly, most of the sections of inner music were short—80.25% of sections lasted less than 30 seconds—but there were some music sections that lasted notably longer—11.72% of sections lasted over 1 minute. Both episode length (ICC = .31) and section length (ICC = .35) were primarily a function of within-person factors. Although most episodes and sections of music were relatively short, people did experience long episodes and sections of music,

which demonstrates that there is variability in length across episodes. This variability supports length's inclusion as a dimension of inner music.

Summary. The descriptive statistics from each of the five proposed dimensions show considerable variation between episodes. This variability supports the proposed dimensional approach to musical imagery. If there were a dominant type of experience, such as the earworm, responses on the inner music items would yield limited variability around a singular, dominant response. As this does not appear to be the case, musical imagery appears to be a heterogeneous experience instead of a phenomenon that predominantly manifests as a prototypical experience.

Within-Person Inner Music Correlations

I next consider the within-person correlations among the inner music items. For these correlations, the relationship is at the episode level. For example, this means that for a given episode, that episode has responses for the enjoyment and lifelikeness of that individual episode. Each person has many episodes, so the relationships between the items are calculated for each person, and each person has a correlation matrix based only upon his or her responses (see Nezlek, 2001). Because these correlations are based on just one person's experiences, they are not confounded by between-person factors, such as personality—all the responses originate from one person whose personality remains constant across all episodes. Within-person correlations are thus independent of between-person differences. The overall within-person correlations, reported below, are estimated based upon the correlation coefficients for each of the 132 participants—these can be thought of as a weighted average of each person's correlation matrix. The correlations

represent the typical relationships among qualities within this sample—the individual correlations for each person may vary around the pooled, overall within-person correlation for the sample.

Relationships within dimensions are expected to be stronger than those between dimensions. This would demonstrate that these dimensions are related, but separate, characteristics of musical imagery experiences and would support the proposed dimensional structure. Table 1 contains the within-person correlations among the musical imagery items. These correlations can be viewed as effect sizes (Cumming, 2012), with *r*s of .10, .30, and .50 indicating small, medium, and large effects, respectively.

Relationships within dimensions. The two *Affective Valence* items—enjoyment and not wanting to have inner music (*reversed*)—were positively related ($r = .22$). Though this relationship is smaller than may be expected for items tapping the same dimension, this may be due to low variability in responses on these items—the overwhelming majority of responses used only the upper half of the response scale.

The *Vividness* items were more strongly related. Lifelikeness and the degree to which the inner music was like listening to the song were strongly, positively related ($r = .60$). Movement's relationships with lifelikeness ($r = .25$) and listening ($r = .30$) were moderate in size. Since the movement item requires external engagement and the other two *Vividness* items are solely about the internal experience, the items may be tapping different components of vividness, accounting for the smaller relationship between the movement and internal vividness items. Alternatively, this may suggest that movement should be considered its own independent dimension.

The two items making up the *Initiation* aspect of the *Mental Control* dimension were strongly and positively related (r = .79). The relationships among the *Maintenance* items were somewhat weaker. Feeling the inner music was under control was moderately related to keeping the music playing (r = .40) and being able to stop the mental music (r = .49). The relationship between keeping the music playing and being able to stop the music was moderate (r = .24). Intuitively, this relationship may be expected to be negative, but it is the perception of being able to stop the inner music that is assessed, not actually exerting control and stopping the music. This may account for the small but positive relationship between these items.

The relationships between the *Initiation* and *Maintenance* items ranged from small to large effect sizes. The strongest relationships were between the *Initiation* items and keeping the inner music playing (rs = .48 and .51). If people initiated their musical imagery, they were also likely to say they were keeping the music playing. There were moderate relationships between feeling the mental music was under control and initiation of music imagery (rs = .37 and .38). Feeling that the inner music was under control was associated with having initiated the inner music episode. The *Initiation* items had smaller relationships with perceived ability to stop the musical imagery episode (rs = .28 and .26).

The final dimension, *Length,* yielded a moderate, positive relationship between the length of the section of music and the length of the episode (r = .35). Longer sections of music were associated with longer episodes of musical imagery.

Relationships between dimensions. Relationships between the proposed dimensions were small and moderate in magnitude. *Affective Valence* was most strongly related to the three *Vividness* items (*r*s = .24 to .29) but also had small relationships with both components of *Mental Control* (*r*s = .16 to .25) and *Length* (*r*s = .17 to .22). *Repetitiveness* was negatively related to all dimensions except *Affective Valence*—these dimensions were unrelated. Its strongest relationship was with the length of the section of music (*r* = -.26)—repetitive musical imagery tended to have shorter sections of music. The two traditional *Vividness* items—lifelikeness and similarity to listening to the song—were associated with higher levels of mental control (*r*s = .15 to .28), longer episodes (*r*s = .14 and .16), and longer sections of music (*r*s = .24 and .29). Movement triggered by the musical imagery was associated with *Mental Control* (*r*s = .17 to 31), longer episodes (*r* = .13), and longer sections of music (*r* = .21). *Initiation* was most strongly related to the length of musical section (*r*s = .28 and .29) but was weakly related to episode length (*r*s = .13 and .16). Keeping the mental music playing was the only *Maintenance* item related to both episode length (*r* =. 17) and section length (*r* = .26). Feeling the music was under control was weakly associated with section length (*r* = .15).

Summary. The correlations among the inner music items demonstrate that relationships within the dimensions are stronger than those between dimensions. This is important, as it demonstrates that, although related, each of the five proposed dimensions are independent from one another. Additionally, this suggests that there are at least five dimensions that can be used to evaluate musical imagery experiences. These relationships support the contention that musical imagery does not exist as a single dominant

experience. If there were a dominant experience, relationships between certain dimensions, such as *Affective Valence, Repetitiveness,* and *Mental Control*, would expected to be larger, as these are the core features of the earworm experience.

Within-Person Mood and Environment Relationships with Inner Music Dimensions

Within-person relationships between the qualities of musical imagery and the person's mood and environment during the inner music episode can be found in Table 2. (For interested readers, descriptive statistics and correlations for the mood and environment items are displayed in Table 3.) The examination of these relationships is exploratory, and the intention is to see what mood or environmental factors, if any, relate to the qualities of musical imagery experiences.

Frequency. Whether or not someone was experiencing musical imagery at any given signal was not related to his or her mood or environment assessed in this study.

Affective valence. The valence of inner music was positively associated with a range of positive mood states, including feeling happy, relaxed, and excited (*r*s = .13 to .34)—the strongest of these relationships was between the enjoyment of the inner music and feeling happy (*r* = .34). Additionally, enjoyment was positively related to being in a pleasant situation (*r* = .19). *Affective Valence* was negatively, but less strongly, related to unpleasant mood states, such as feeling irritated or bored (*r*s = -.18 to -.10). Overall, *Affective Valence* is related to a handful of mood states and environmental factors, but these relationships were moderate at best.

Repetitiveness. *Repetitiveness* was largely unrelated to mood and the environment. The only notable relationship is that repetitive episodes were less frequent when there was also music playing in the environment (r = -.27).

Vividness. The *Vividness* items, similar to *Affective Valence,* were primarily associated with positive mood states. The strongest relationships were seen with feeling happy (rs = .21 to .23), but the three items were also associated with feeling relaxed and excited (rs = .10 to .19). In the presence of environmental music, people reported more vivid musical imagery (rs = .15 to .20). Additionally, moving along with the mental music was less frequent when people were feeling sad (r = -.13). Again, there were some relationships between musical imagery qualities and mood and the environment, but these relationships were weak.

Mental control. Both aspects of *Mental Control* were positively associated with feeling happy, relaxed, and excited (rs = .11 to .24). *Initiation* and *Maintenance* were also related to being in a pleasant situation (rs = .11 to .16) and hearing music in the environment (rs .14 to .22). It appears that musical imagery is more controlled when in a positive state of mind or when environmental music is present.

Length. The length of the section of music was weakly associated with feeling a range of emotions: happy (r = .12), bored (r = -.13), excited (r = .10), and tired (r = -.11). Section length was most strongly related to the presence of environmental music—longer section lengths were associated with hearing music in the environment (r = .24). Episode length was unrelated to all mood states and environmental factors.

Summary. Collectively, the dimensions of musical imagery experiences are not strongly related to the mood people are in or aspects of their environment. The strongest relationship—enjoyment of the episode and feeling happy—was only moderate. This suggests that the qualities of musical imagery experiences are not greatly influenced by mood or environmental factors.

Between-Person Inner Music Descriptive Statistics

With nested data, I am also able to look at the relationships among the dimensions at the between-person level. Given the high variability in the number of responses completed by each participant (*range* = 5 to 80), calculating the simple mean for each individual introduces concerns regarding the reliability of the individual means—some people have fewer episodes to draw from. Instead, Mplus 7 estimates a person's mean for each item (Lüdtke et al., 2008). All between-person descriptive statistics can be found in Table 1.

Frequency. On average, people experienced inner music 25% (*SD* = 17%) of the time. There was a considerable range of how frequently people had musical imagery experiences—some people almost never experienced musical imagery (*minimum* = 2%) whereas others heard inner music almost constantly (*maximum* = 86%). Most people (65%) heard inner music less than 30% of the time—only 8 people (6%) had a frequency of musical imagery greater than 50% (see Figure 3, panel a). Even with this wide range, all participants reported experiencing musical imagery at least occasionally, further reinforcing that musical imagery is a common phenomenon.

Affective valence. As would be expected from the within-person findings, people viewed their musical imagery favorably (*M*s = 5.22 and 5.99). Enjoyment of musical imagery ranged from tending to view musical imagery somewhat negatively (*minimum* = 3.29) to enjoying all inner music episodes (*maximum* = 7.01). Wanting the inner music to keep playing demonstrated less variability (*range* = 4.99 to 6.96)—everyone tended to want their inner music to continue to some degree. Even with the variability in *Affective Valence*, most people have a tendency to see musical imagery as a positive experience (see Figure 3, panels b and c).

Repetitiveness. On average, participant's musical imagery was repetitive most of the time (72%). For some, every inner music experience was repetitive but for others, repetitiveness was less frequent (*minimum* = 25%). Even with this wide range, a sizeable portion of people's inner music is repetitive. Most people (75%) reported repetitive musical imagery in over 60% of their episodes (see Figure 3, panel d)

Vividness. Based on the within-person findings, lifelikeness and similarity to the actual song, were the core of the *Vividness* dimension. People reported moderate levels of vividness on these two items (*M*s = 4.64 and 4.67 respectively). Both items demonstrated that some people tend to have very vivid musical imagery (*maximums* = 6.80 and 6.73 respectively) whereas others do not experience vivid inner music (*minimums* = 1.99 and 2.13 respectively). About a quarter of participants tended to have musical imagery that is not vivid (see Figure 3, panels e and f), so most people seem to have a tendency for at least moderately vivid inner music. Movement, the third vividness item, followed a similar pattern. People endorsed moderate levels of movement to their musical imagery

(*M* = 3.50), though there was a considerable range in the tendency to move along to musical imagery (*minimum* = 1.27; *maximum* = 6.22). Only 37% of people experienced at least moderate levels of movement to their inner music (see Figure 3, panel g).

Mental control. The *Initiation* component of the *Mental Control* dimension at the between-person level was similar to the within-person level. On average, people endorsed low levels of initiation of their inner music (*M*s = 3.22 and 3.29). Though the majority of people tended to have low levels of initiation (see Figure 3, panels h and i), there was variability—some people never initiated their inner music (*minimums* = .92 and 1.00) whereas some people had a stronger tendency to start their musical imagery (*maximums* = 6.22 and 6.26).

The *Maintenance* component yielded slightly higher averages (*M*s = 3.96, 3.35, and 4.17) but had a similar profile to the *Initiation* component—some people reported little maintenance ability (*minimums* = 1.04, 1.20, and 1.27) whereas others strongly endorsed maintaining their musical imagery (*maximums* = 6.42, 6.52, and 7.00). Similar to the within-person distributions, the between-person distribution for trying to keep the inner music playing was skewed, similar to those of the *Initiation* items (see Figure 3, panel k). The distributions for being able to stop the inner music and feeling like the music is under one's control were more normally distributed (see Figure 3, panels j and l).

Length. The majority of people (65%) tended to experience very short musical imagery episodes of less than one minute (see Figure 3, panel m). A portion of the participants tended to have slightly longer episodes lasting between one and five minutes

(34%). Only one person reported a tendency to experience episodes lasting longer than five minutes.

The section length findings followed a similar pattern (see Figure 3, panel n)—most people (83%) tended to have short sections of inner music (less than 10 seconds). A handful of people (13%) averaged music sections between 10 and 30 seconds long, and very few tended to have section lengths longer than 30 seconds (4%).

Summary. What can be drawn from the between-person findings is that, just like individual episodes vary, people's collections of musical imagery episodes vary. For example, some individuals tended to report low levels of mental control over their musical imagery—there very may well be some episodes where these individuals exert high levels of control over their inner music, but they tend not to. The frequency of inner music and each of the five dimensions exhibited between-person variation, demonstrating that people do differ in their collections of musical imagery experiences. However, it is important to remember that within these collections of experiences, there are still differences from episode to episode.

Between-Person Inner Music Correlations

I next consider the correlations among the inner music items at the between-person level (see Table 1 for all correlations). These correlations, unlike the within-person correlations, are based on people's mean responses to the items. Responses for each participant are pooled for each of the ESM items—the between-person correlations are computed using these pooled values. It is important to note that although the same data are used to calculate the within and between-person correlations, these correlations

are independent of one another (see Nezlek, 2001). Just because a within-person correlation is positive does not mean the between-person correlation will also be positive.

Like at the within-person level, stronger relationships within rather than between dimensions support the contention that these dimensions are related but separate components of musical imagery experiences.

Relationships within dimensions. The *Affective Valence* items were strongly related to one another (r = .74)—people who tended to enjoy their musical imagery also tended to want the music in their mind.

The three *Vividness* items demonstrated relationships that were similar to those found at the within-person level. Lifelikeness and feeling as if you were listening to the actual song were very strongly related (r = .90), so people who tended to experience lifelike inner music also tended to feel that the music was like listening to the actual song. People who tended to move along with their inner music also tended to have lifelike inner music (r = .48) and tended to feel that it was similar to the actual song (r = .44). The relationships with movement, however, were not as strong. This suggests that, like at the within-person level, moving along to musical imagery may be assessing a different aspect of vividness rather than the traditional lifelikeness or similarity to the actual song.

The two *Initiation* items from the broader *Mental Control* dimension were very strongly related to one another (r = .98)—people who tended to start their inner music also tended to say that they began the episode on purpose. The strongest relationship of the *Maintenance* component was between feeling as if the inner music was under your control and that the music could be stopped (r = .94) meaning that people who tended to

think their inner music was under control also tended to say that they would be able to stop the episode if they chose to do so. Actively keeping the inner music playing was less strongly related to both feeling control over the imagery (r = .71) and feeling like you are able to stop the music (r = .67)—participants who tended to keep their inner music going also tended to perceive control over these episodes. This may be because keeping the music playing is assessing actual use of mental control whereas the other items ask about perceptions of control. All five of the *Mental Control* items were positively related to one another (rs = .61 to .77).

The two *Length* items were positively related to one another (r = .58). Similar to the relationship at the within-person level, people who had a tendency to experience longer musical imagery episodes also heard longer sections of music.

Relationships between dimensions. Frequency of people's inner music experiences was related to three of the five dimensions. The movement aspect of the *Vividness* dimension was negatively related to frequency of musical imagery (r = -.33)—those who experienced more frequent inner music tended to move along with the music less. The other *Vividness* items were unrelated to frequency. Both components of *Mental Control* were negatively related to frequency of inner music (rs = -.36 to -.23)—use of control in musical imagery occurred more in individuals who experience musical imagery less frequently. Both episode length (r = .20) and section length (r = .22) were positively related to frequency—people who experience more inner music tended to have longer episode and section lengths. *Repetitiveness* showed a weak positive association with frequency (r = .10).

The *Affective Valence* items were related to three other dimensions. Both items were positively related to all three *Vividness* items (*r*s = .21 to .52), but these relationships were stronger for the enjoyment ESM item meaning that people who tended to view their inner music positively also tended to experience more vivid musical imagery. Only the enjoyment item was related to the *Initiation* items (*r*s = .25 and .27)—people who tended to intentionally begin their musical imagery episodes also tended to enjoy them more. Both items were related to the *Maintenance* component (*r*s = .14 to .47). Individuals who tend to exert control over their musical imagery seem to also view their inner music favorably. People who tended to experience longer section lengths also tended to have more positive musical imagery (*r*s = .21 and .39).

Repetitiveness was related to three dimensions—*Vividness, Mental Control* and *Length.* The two core *Vividness* items—lifelikeness and similarity to the actual song—were weakly associated with repetitiveness (*r*s = .17 and .19, respectively)—people who experienced repetitive inner music more frequently tended to also have more vivid experiences. Repetitiveness was unrelated to moving along to the internal music. Both aspects of *Mental Control* were negatively related to repetitiveness—this relationship was stronger for the *Maintenance* items (*r*s = -.35 to -.33) than the *Initiation* items (*r*s = -.30 and -.27). People who tended to exert control over their musical imagery had a tendency to experience non-repetitive musical imagery. Repetitiveness was also negatively related to section length (*r* = -.23)—people who tended to have repetitive inner music also tended to experience shorter section lengths.

All three *Vividness* items were related to the *Mental Control* and *Length* dimensions. The lifelikeness of the inner music and similarity to the actual song were related to all *Mental Control* items (*r*s = .18 to .38), but their relationships with actively keeping the musical imagery playing were strongest (*r*s = .38 and .37, respectively). The movement item followed the same pattern—movement was related to all control items, and its strongest relationship was with keeping the music going (*r* = .58). Interestingly, moving along with the inner music was more strongly related to control than the two core *Vividness* items (*r*s = .28 to .58). Overall, people who tended to have vivid inner music also had a tendency to exert control over these episodes. All three *Vividness* items demonstrated moderate, positive relationships with the episode (*r*s = .31 to .35) and section lengths (*r*s = .37 to .43)—people who tended to have longer episode and section lengths also tended to have more vivid musical imagery experiences.

Both components of *Mental Control* were related to *Length.* The *Initiation* component was weakly related to section length (*r*s = .14 and .20), but only starting inner music on purpose was related to episode length (*r* = -.16). Section length's relationship with *Maintenance* was stronger than for *Initiation* (*r*s = .25 to .45). Two *Maintenance* items—feeling like you can stop the imagery and feeling the music is under control—were negatively related to episode length (*r*s = -.17 and -.15, respectively). People who perceive control over their inner music also tend to have longer section lengths but shorter musical imagery episodes. Actively trying to keep the internal music playing was weakly, but positively, associated with episode length (*r* = .10)—people who tend to try

to keep their musical imagery experiences going also tended to have longer episodes of inner music.

Summary. The strong relationships among the inner music items within each dimension suggests that these items are assessing the same dimension. The relationships between the dimensions, which are not as strong as those within dimensions, provide evidence for treating these dimensions as separate but related components of inner music experiences. This pattern of results, similar to those at the within-person level, support taking a dimensional approach to musical imagery.

Between-Person Mood and Environment Relationships with Inner Music Dimensions

Next, I explore the relationship between the inner music experience and mood and environmental factors (see Table 4 for all correlations).

Frequency. Frequency had only one notable association with the environment—people who had frequent musical imagery tended to also be listening to music in their environment at the same time (r = .22).

Affective valence. *Affective Valence* was associated with both positive and negative mood states. These relationships were in the expected directions—people who tended to be in positive states (i.e., happy, relaxed, excited) tended to view their inner music favorably (rs = .30 to .55), and people who tended to be in negative states (i.e., stressed, irritated) did not want to experience musical imagery (rs = -.39 to -.33). Additionally, people who tended to enjoy their inner music also tended to be listening to music in their environment during their episodes (r = .22).

Repetitiveness. *Repetitiveness* of inner music was weakly associated with a tendency to feel bored (r = .13) and irritated (r = .17). People who tended to have lower degrees of interaction with others during their inner music episodes also tended to have repetitive musical imagery (r = -.13).

Vividness. The two traditional *Vividness* items and moving along to internal music had slightly different relationships with mood. The traditional items were primarily associated with positive moods, such as feeling happy and excited (rs = .21 to .42). Movement was associated with multiple positive (rs = .26 to .32) and negative states, including feeling irritated or bored (rs = .22 to .31).

Mental control. The *Initiation* component of *Mental Control* primarily related to negative mood states—people who initiated musical imagery episodes tended to do so when feeling bored (rs = .31 and .37), sad (rs = .27 and .28), irritated (rs = .28 and .32), and stressed (rs = .26 and .28). *Initiation*'s strongest relationship, however, was with feeling excited (rs = .53 and .56). Initiation of musical imagery was less frequent when environmental music was present (rs = -.25 and -.25). The *Maintenance* items demonstrated two patterns of association. People's perceived control over their internal music was positively related to feeling bored (rs = .22 and .26) and excited (rs = .29 and .37). Active use of control—trying to keep the music playing—was associated with several negative states (rs = .24 to .40) but also with feeling excited (r = .48) and being in a pleasant situation (r = .23).

Length. *Length* had few relationships with mood states and the environment. A tendency to experience longer episodes was associated with feeling tired (r = .25) and

being in a pleasant situation (r = .27). Section length had weak relationships with positive moods (r = .12 to .18), and longer sections were associated with higher degrees of interaction with others (r = .18).

Summary. Overall, inner music's relationships with mood states and the environment showed few large effects. The qualities of inner music were most strongly related to positive moods, though there were some qualities (i.e., *Mental Control* and movement) that were also related to negative moods. Environmental factors (i.e., being alone and the presence of music in the environment) were largely unrelated to the qualities of musical imagery.

Personality Predicting Inner Music Dimensions

To further evaluate the proposed dimensions, I examined the relationships between the inner music items and the five-factor model of personality. I first review the notable correlational relationships between the personality facets and the inner music items (see Table 5). I also use the five personality factor scores as predictors of the musical imagery items in multilevel models (see Table 6). Given the substantial overlap of facets within each personality factor, it would not make sense to consider them in a model simultaneously, so for the regression analyses, only the five factors are used as predictors. Internal consistency was acceptable for the five personality factors; the reliability estimates for the factors and associated facets can be seen in Table 5.

Frequency. Some of the facets from each of the five personality factors were related to frequency, but these were all small effects save three of the openness to experience facets (Fantasy, Aesthetics, and Feelings; rs = .32 to .41). In the regression

analyses, openness to experience was the strongest predictor of the frequency of inner music (β = .39, p < .001, 95% CI [.24, .55]). Extraversion was the other significant predictor of frequency (β = .20, p = .010, 95% CI [.05, .36]). No other personality factors predicted how often people experience musical imagery.

Affective valence. Only two correlational relationships with personality were a medium effect size—the Altruism facet of agreeableness (r = .33) and the Self-Discipline facet of conscientiousness (r = .33). Although none of the personality factors were significant predictors of the two affective valence items, extraversion was a marginal predictor of enjoyment (β = .19, p = .086, 95% CI [-.03, .41]) and conscientiousness was a marginal predictor of wanting music in one's head (β = .20, p = .078, 95% CI [-.02, .42]).

Repetitiveness. No correlational relationships were greater than a small effect. None of the personality factors predicted repetitiveness.

Vividness. Only one correlational relationship was greater than a small effect—similarity to the real song and the Dutifulness facet of conscientiousness (r = .33). Lifelikeness and similarity to the actual song were not predicted by the personality factors. Movement, on the other hand, was predicted by both extraversion (β = .21, p = .043, 95% CI [.01, .42]) and openness to experience (β = -.22, p = .030, 95% CI [-.41, -.02]).

Mental control. The *Initiation* items were most strongly related to the Fantasy and Aesthetics facets of openness to experience (rs = -.40 to -.36). These items were negatively predicted by openness to experience and agreeableness. Starting the music on

purpose was more strongly predicted by openness to experience (β = -.33, p = .001, 95% CI [-.52, -.14]) than by agreeableness (β = -.17, p = .047, 95% CI [-.34, .00]). Intending to start the inner music followed a similar pattern—openness to experience was a stronger predictor (β = -.38, p < .001, 95% CI [-.56, -.20] than agreeableness, which was a marginal predictor (β = -.16, p = .067, 95% CI [-.33, .01]).

The *Maintenance* items were related to all facets of openness to experience and were small and medium effects (*r*s = -.42 to -.14). The perceived control items were also related to the Vulnerability facet of neuroticism (*r*s = -.38 and -.39). Openness to experience predicted all three of the *Maintenance* items. The relationship was strongest for trying to keep the musical imagery experience going (β = -.42, p < .001, 95% CI [-.61, -.23]); the relationships for the perceived control items—being able to stop the imagery (β =-.28, p = .003, 95% CI [-.46, -.09]) and feeling the inner music is able to be controlled (β = -.36, p < .001, 95% CI [-.54, -.17])—were somewhat smaller. Neuroticism was a marginal predictor of being able to stop the inner music episode (β = -.21, p = .059, 95% CI [-.43, .01]).

Length. There were no notable correlational relationships between the length items and the personality facets. Personality factors, however, did predict the length items. Episode length was significantly predicted by neuroticism (β = .24, p = .016, 95% CI [.05, .44]) and marginally predicted by extraversion (β = .17, p =.096, 95% CI [-.03, .37]) and agreeableness (β = .17, p = .088, 95% CI [-.03, .36]). Section length was predicted by extraversion (β = .30, p = .005, 95% CI [.09, .51]).

Summary. Openness to experience was clearly the personality factor most widely related to the musical imagery items—it was related to frequency, movement, and all five *Mental Control* items. Interestingly, except for frequency, all of these relationships were negative—open people were less likely to move along with their inner music or to exert control over it. Extraversion was the only other personality factor related to multiple qualities of musical imagery: frequency, movement, and section length. These relationships, on the other hand, were positive—extraverts experienced more frequent inner music, were more likely to move along with their music, and to experience longer sections of musical imagery. Neuroticism was associated with longer episodes of internal music, and agreeable people were less likely to initiate their musical imagery episodes. Overall, most of the action was with openness to experience and extraversion with a few notable associations between inner music and neuroticism, agreeableness, and conscientiousness.

Musical Expertise and Auditory Imagery Ability Predicting Inner Music Dimensions

Musical expertise and general auditory imagery ability were considered together—Table 7 displays the descriptive statistics and correlations among the GMSI and BAIS factors. I first review the notable correlations, if any, between the inner music items and musical expertise and auditory imagery ability (see Table 8 for all correlations). I then use multilevel models to examine the unique ability of each of the individual difference factors to predict the musical imagery items (see Table 9). I exclude the *General Sophistication* composite scores from the multilevel analyses given that it is

formed by the four individual factors from the GMSI. Internal consistency for the GMSI and BAIS factors was acceptable and can be seen in Table 7.

Frequency. The frequency with which people experienced musical imagery was moderately related to all five of the musical expertise scores (*r*s = .34 to .49). Its relationship with musical training, a common marker of musical expertise, was one of the strongest relationships (*r* = .48). Frequency was not related to BAIS Vividness or Control scores.

Musical Training was the only significant predictor of frequency of inner music (β = .39, *p* = .002, 95% CI [14, .64]). People with more musical training experienced musical imagery more frequently.

Affective valence. Valence was largely unrelated to musical expertise—both items had small relationships with *Perceptual Abilities* (*r*s = .12 and .15) and wanting the music in their head with *Emotions* (*r* = .10) and *Musical Training* (*r* = -.15). Both items were related to BAIS Control (*r*s = .11 and .22), and overall enjoyment of musical imagery was also related to BAIS Vividness (*r* = .16).

Wanting the musical imagery to continue was predicted by both the BAIS Control (β = .29, *p* = .028, 95% CI [.03, .55]) and *Musical Training* (β = -.39, *p* = .010, 95% CI [-.69, -.10]. People with higher BAIS Control scores or who had less musical training tended to want their inner music to continue. Both *Affective Valence* items were also marginally predicted by *Perceptual Abilities* (Enjoyment: β = .34, *p* = .063, 95% CI [-.02, .71]; No Music (*reversed*): β = .38, *p* = .064, 95% CI [-.02, .78]). More positive views of musical imagery related to having better perceptual abilities concerning music.

Repetitiveness. *Repetitiveness* was weakly associated with BAIS Vividness scores (r = .13) and negatively related to three musical expertise factors (*Active Engagement, Musical Training,* and *General Sophistication*; rs = -.14 to -.11).

None of the auditory imagery or musical expertise measures predicted repetitiveness.

Vividness. As would be expected, the inner music *Vividness* items were related to BAIS Vividness scores. This relationship, however, was notably weaker for movement (r = .18) than the lifelikeness of the imagery (r = .42) and similarity to the actual song (r = .48). The two core *Vividness* items were related also related to BAIS Control scores (rs = .20 and .22), *Perceptual Abilities* (rs =.10 and .16), *Emotions* (rs = .12 and .20), and *Active Engagement* (rs = .10 and .15). In contrast, movement was negatively related to *Emotions* (r = -.13), *Musical Training* (r = -.16), and *General Sophistication* (r = -.14).

The BAIS Vividness scores predicted lifelikeness (β = .41, p = .001, 95% CI [.17, .65]), feeling like you are listening to the actual song (β = .51, p < .001, 95% CI [.28, .75]), and moving along with the inner music (β = .28, p = .025, 95% CI [.04, .53]). Similar to the correlational relationships, movement to musical imagery was less strongly related to BAIS Vividness scores than the two core vividness items. Movement was marginally associated with *Musical Training* (β = -.31, p = .076, 95% CI [-.65, .03])—people with more music training moved along with their musical imagery less often.

Mental control. Interestingly, BAIS Control scores were largely unrelated to the inner music *Mental Control* items—there was only a weak, negative relationship between this factor and initiating the musical imagery on purpose (r = -.11). Both *Initiation* items

were related to BAIS Vividness scores (*r*s = .18 and .22). Trying to keep the inner music playing was the only *Maintenance* item related to BAIS Vividness (*r* = .21). All *Mental Control* items were related to musical expertise—the most consistent relationships were with *Emotions* (*r*s = -.21 to -.13), *Musical Training* (*r*s =-.28 to -.16), and *General Sophistication* (*r*s = -.23 to -.14).

BAIS Vividness scores predicted both *Initiation* items (Purpose: β = .44, *p* < 001, 95% CI [.25, .64]; Start: β = .37, *p* = .001, 95% CI [.15, .59]). People who were able to create vivid auditory images tended to initiate their musical imagery episodes. Initiating inner music on purpose was negatively predicted by BAIS Control scores (β = -.27, *p* = .004, 95% CI [-.45, -.09]). People who were skilled at manipulating their auditory images tended to not start their inner music. *Maintenance* items were predicted by the BAIS Vividness and Control scores and perceptual abilities related to music. Specifically, trying to keep the inner music playing was predicted by vividness (β = .43, *p* < .001, 95% CI [.20, .67]) and control (β = -.27, *p* = .040, 95% CI [-.52, -.01]). People who generate vivid auditory imagery or struggle to control these images tended to exert control to continue their musical imagery episodes. Perceiving the ability to stop a musical imagery episode was predicted by *Perceptual Abilities* (β = .32, *p* = .021, 95% CI [.05, .60]) and was marginally associated with *Musical Training* (β = -.29, *p* = .056, 95% CI [-.59, .01]).

Length. Section length was associated with all aspects of musical expertise and auditory imagery ability. Its strongest relationships were with *Active Engagement* (*r* = .25) and *General Sophistication* (*r* = .21). Episode length was also related to both factors

of auditory imagery ability and all of the musical expertise factors, except *Singing Abilities.* Episode length was most strongly related to *Musical Training* (r = .28).

Neither episode length nor section length were predicted by auditory imagery abilities or musical expertise.

Summary. Although all aspects of musical expertise and auditory imagery ability were correlated with a variety of inner music items, the ability to produce vivid auditory images was the most common predictor of the qualities of musical imagery. The ability to control auditory images, interestingly, was a negative predictor of *Mental Control* items. Perhaps people who are able to control their auditory images simply choose not to control their inner music episodes. Musical training, a commonly use index of expertise, related only to the frequency of musical imagery episodes and the general enjoyment of inner music. Perceptual abilities related to music was the only other factor of musical expertise that predicted inner music items.

Relationships Between Retrospective and In-The-Moment Measurement of Inner Music

The purpose of examining the relationships between the ESM items and IMIS factors was to evaluate whether in-the-moment and retrospective reports of inner music line up. For this reason, I only focus on the ESM items that align with one of the IMIS factors—frequency, both affective valence items, movement, if the music is distracting, and episode and section length (see Table 10). For the frequency and length factors, I examine the correlational relationship between the two methods of measurement. Table 11 contain the descriptive statistics and correlations among the ESM items and the IMIS

factors. For the other inner music qualities (affective valence, movement, and distracting), a multivariate model was estimated: the four IMIS subscales (*Negative Valence, Movement, Personal Reflections,* and *Help*) were predictors of the four ESM items. Table 12 displays the results. Internal consistency was good for the IMIS subscales (see Table 11).

Frequency. The correlation between the IMIS Frequency item (see Table 11) and how often people reported inner music in daily life was notable in size: r = .43. Thus, it appears that the frequency of musical imagery is salient and memorable.

Length. For section length, the IMIS item asking people to describe their imagery's typical section length (see Table 11) was essentially uncorrelated to the section lengths reported in vivo: r = .11. People thus seem to lack insight into section length. For episode length, in contrast, people's self-reported typical episode length (see Table 11) was strongly related to in vivo ratings: r = .56. The effect size is large in size and suggests that the knowledge people draw upon to report typical episode lengths is valid.

Qualities of musical imagery. *Negative Valence,* the largest subscale in the IMIS, had two corresponding ESM items: "I enjoy hearing the music in my mind" and "I would rather not have music in my head right now" (reverse scored). The IMIS *Negative Valence* subscale significantly predicted in vivo ratings of enjoying hearing the music (β = -.25, p = .049, 95% CI [-.50, .00]), but it had a stronger effect on preferring to have music in one's mind (β = -.35, p = .010, 95% CI [-.61, -.08]). The effects were in the expected direction (people who reported typically experiencing negative musical imagery reported less enjoyment in daily life), and they were medium in effect-size terms.

The IMIS *Movement* subscale had one corresponding ESM item: "My body is responding to the music (feet tapping, head and body moving)." This item, however, was not significantly associated with the *Movement* subscale (β = .11, p = .36, 95% CI [-.13, .35]).

Finally, the IMIS *Help* subscale was addressed by one ESM item: "The music in my mind is distracting me from other things." The *Help* subscale was not a significant predictor of finding musical imagery distracting (β = -.06, p = .64, 95% CI [-.30, .18]).

Summary. The different patterns of effects for the ESM and IMIS can be distilled down to a few key findings. The ESM and IMIS measures of frequency of musical imagery and the length of episodes had good agreement—these aspects of the experience are salient and generally remembered and can be pooled reasonably well. For the remaining qualities of inner music, there was some agreement (i.e., valence) but not for all aspects. Overall, this suggests that ESM and retrospective measures are similar in their measurement of the most salient qualities of inner music but not for more fleeting aspects of the experience.

CHAPTER IV

DISCUSSION

The present research proposed a dimensional framework to examine musical imagery experiences. There were four primary aims of this project: (1) to evaluate the five dimensions and the appropriateness of their inclusion in the model; (2) to explore how the qualities of musical imagery relate to people's moods and environments during these experiences; (3) to examine the dimensions' relationships with three individual differences—personality, musical expertise, and auditory imagery ability; and (4) to compare ESM and retrospective survey techniques for measuring musical imagery experiences.

Inner Music Dimensional Structure

This project identified five fundamental dimensions of musical imagery—*Affective Valence, Repetitiveness, Vividness, Mental Control,* and *Length*. Each of these dimensions demonstrated considerable within-person variability, suggesting that there are many fluctuating aspects of musical imagery and demonstrating that each warrants inclusion into the model. Furthermore, the relationships among the inner music items shows that these dimensions are distinguishable from one another—relationships were stronger for items within the same dimension than in cross-dimensional correlations. This was true at both the within and between-person level. Overall, the present findings support the use of a dimensional model of musical imagery.

Although prior work has looked at some of these qualities of musical imagery (e.g., Bailes, 2007, 2015; Beaty et al., 2013; Cotter et al., 2016; Liikkanen, 2011), it has not used a formal model to examine these qualities simultaneously and, in addition, has almost exclusively used a typology approach, typically focusing on earworms (e.g., Beaman & Williams, 2010, 2013; Floridou & Müllensiefen, 2015, Floridou et al., 2015). The present work shows that assuming a wide range of people are only having a singular, specific type of experience is likely inaccurate. There is simply too much variability across a number of factors in these experiences. In moving away from a typology approach, we are now able to consider other musical imagery experiences that exist and can be examined under a dimensional framework but would never be studied as a part of the earworm or involuntary musical imagery traditions (e.g., mental rehearsal, composition, or improvisation). Based upon the present work, there is too much variability to assume there is a singular dominant experience—a dimensional model is feasible and appears more appropriate for studying the diversity of inner music in the real world.

Inner Music Relationships with Mood and Environment

How do the qualities of inner music relate to people's moods and environments? At both levels of analysis, all mood factors were related to the qualities of musical imagery. It appears that positive states—including feeling happy, excited, and relaxed, or being in a pleasant situation—enhance several qualities of musical imagery, such as the enjoyment and vividness of the experience. Positive moods were associated with enjoying the inner music experience and also having more vivid musical imagery. But

several negative states—such as feeling bored, sad, and irritated or being in a stressful situation—were also associated with inner music (i.e., *Affective Valence, Vividness*, and *Mental Control*). When people were in these negative moods, they tended to enjoy their inner music less but would move along more to their inner music and exert higher levels of control over the experience. Aspects of the environment, such as hearing music in the environment while also hearing inner music, were also associated with the valence and vividness of the musical imagery episodes. Being alone or with others didn't seem to influence the frequency or qualities of musical imagery.

Overall, there were somewhat consistent relationships with the valence and vividness dimensions, but none of these relationships were extraordinarily strong. This suggests that how often inner music occurs and the qualities of these experiences are largely independent of the mood and environmental factors explored here. People can have similar experiences under varying circumstances. Perhaps there are some aspects of the environment that were not addressed in the present study, such as the activity someone is engaged in, that are more strongly related to inner music experiences.

Inner Music Relationships with Individual Differences

Who tends to hear inner music, and how do their experiences vary? I first investigated how personality relates to musical imagery experiences. As predicted, openness to experiences was the personality trait most widely related to inner music. Consistent with past work (Beaty et al., 2013; Cotter et al., 2016, Floridou et al., 2012), more open people experienced musical imagery more frequently. Interestingly, most of the other relationships were negative—openness negatively predicted all aspects of

mental control and moving along to the inner music. Perhaps open people don't mind letting their musical imagery experiences occur and progress organically without interference and just stay along for the ride. Further research should seek to tease apart this relationship. For movement, however, prior work has found a positive relationship between openness to experience and moving along to internal music (Cotter et al., 2016). This may be due to differences in measurement technique (i.e. retrospective vs. in-the-moment reports; see "Retrospective vs. In-The-Moment Measurement of Inner Music" section below). Extraversion was the only other notable personality factor related to inner music. Extraverts experienced more frequent musical imagery, tended to move along with the music, and experienced longer sections of music.

I also considered how several factors related to musical expertise related to the five dimensions of musical imagery. As research has focused on either being a music major (Bailes, 2006, 2007; Beaty et al., 2013, Clark & Williamon, 2011) or number of years of formal musical training (Liikkanen, 2011), I wanted to consider other potentially relevant factors. As it turns out, musical training is the factor most closely related to inner music—people with more musical training experienced more frequent musical imagery episodes and tended to not want the music to be present in their mind. It should be noted, however, that of the fourteen inner music items, musical training was associated to only two. Thus, it appears that musical training does factor in to the frequency with which someone experiences musical imagery but may not be a major influence on the qualities of inner music experiences.

Finally, I examined how several factors related to musical expertise and auditory imagery ability predicted the frequency and qualities of inner music. The ability to generate vivid auditory images predicted items in two dimensions of musical imagery—vividness and mental control. As would be expected, generally having vivid auditory images was associated with musical imagery that was lifelike and sounds like the actual song. Consistent with prior research, having vivid auditory images was related to more movement with the internal music (Floridou et al., 2015). Vividness was also associated with more frequent initiation of inner music and trying to keep the music playing. The ability to control auditory images, however, was negatively related to initiating musical imagery and trying to continue the music. It is possible that people who are capable of exerting control over their inner music episodes simply choose not to do so. Given the lack of investigation into the use of control in musical imagery, these counterintuitive relationships between the musical imagery items and the ability to control auditory imagery more generally may be an interesting place to start.

Retrospective vs. In-The-Moment Measurement of Inner Music

How accurately do people understand their everyday experience of inner music? Retrospective self-reports and ESM reports were related but less strongly than would be expected if they were measuring the same thing. For two important, global features of inner music—how often imagery happens and how it long lasts—the daily life and retrospective reports agreed reasonably well. Beyond frequency and length, however, ESM and retrospective reports had much weaker relationships, which suggests that they are not based on the same information or judgment processes. The valence of the imagery

experience had moderate correlations between ESM and retrospective methods, and the remaining variables had much smaller effects (see Table 11). From a multi-trait, multi-method perspective, the same trait/different method relationships suggest a sizable effect of method on the measurement of musical imagery.

Why do the two methods for measuring musical imagery align weakly? Although such disparities are common in ESM research, they nevertheless raise interesting questions about how people are understanding and recalling their musical imagery experiences. The first likely reason is the considerable within-person variability of musical imagery episodes. My findings indicate that around 80% of the variance in experiencing inner music is within-person, meaning that the factors that affect whether someone experiences musical imagery are mostly factors that vary within the day, not stable individual differences. For the qualities of musical imagery, the experience of musical imagery in daily life was highly variable. As a result, retrospective reports that require pooling across experiences in an attempt to describe an average or typical experience will be hindered by the volatile nature of the experience. It may be that only the most salient aspects of musical imagery—such as how often it happens and how long it lasts—can be pooled and reported on retrospective measures.

Second, I wonder how deeply people notice and attend to their musical imagery states. Schooler (2002) points out that many experiences are experienced in consciousness but not in *meta-consciousness*. In such cases, people are experiencing something but not judging, reflecting on, or re-representing the experience. Musical imagery, for example, can be experienced (e.g., someone has the opening licks of "Sweet

Home Alabama" running through her mind) without being meta-experienced (e.g., she then notices that the song is playing mentally, labels the song, and thinks about what is playing). People are probably likely to simply experience inner music without additionally paying attention to, thinking about, or evaluating the fact that they are experiencing it. As a result, people are unlikely to deeply encode many, if not most, of their musical images. Much "forgetting" stems from not encoding an event in the first place, so poor initial encoding would be one reason why people's beliefs about their typical imagery experiences diverge from their in-the-moment experiences.

People's beliefs about their typical experience of musical imagery are interesting in their own right, and in a couple respects they align with ESM reports. At the same time, it's clear that people lack insight into the inner soundtrack of everyday life, so some aspects of retrospective reports may be largely measuring people's "personal theories" or good guesses about their experiences (Silvia, Cotter, & Christensen, 2017). Experience sampling is valuable for studying things that people, for whatever reason, can't remember or judge accurately. The fleeting, transient experience of mental music in everyday life looks like one of those things, so I would encourage researchers interested in musical imagery to assess it as close to the experience as possible.

How Do We Move Forward?

The earworm prototype. The present research has many implications for future musical imagery work. The earworm, which has dominated the literature thus far, is actually not the most common experience or apparently even a common one. Since disliking the inner music is the hallmark trait of earworms, the present work suggests that

earworms might not be as common as people believe—only 12.50% of musical imagery episodes were deemed unenjoyable. This is a clear message from the present work but also from past work. Numerous studies have found that inner music is generally a positive experience (e.g., Beaman & Williams, 2010; Beaty et al., 2013; Floridou & Müllensiefen, 2015). Therefore, considering the rarity of earworms in daily life, moving away from focusing on particular types of experiences and towards examining the variation in the qualities of the experience seems appropriate.

A dimensional approach will show the similarity in seemingly different experiences. For example, mental rehearsal can be one slight difference away from an earworm. Mental rehearsal can easily be extremely unpleasant and become repetitive through rehearsing a passage of music but can also be completely under control. A dimensional approach accounts for both of these experiences and sees them as highly similar in that they vary on only one dimension, but this similarity is obscured in a typological approach. This approach also accounts for many other experiences that have not received attention in the literature, such as controlled forms of musical imagery (e.g., composition, improvisation), and makes them directly comparable.

Terminology. Why has this earworm prototype continued to remain so central in musical imagery research? One of the primary issues may be the terminology used in the literature. The most widely used term has been *involuntary musical imagery*, frequently used as a synonym for earworms (e.g., Floridou, Williamson, & Stewart, in press; Liikkanen, 2011). Both of these terms represent specific *types* of experiences but neither captures the breadth of experiences people can have. Although these terms are

appropriate for describing certain kinds of experiences, they have become the ill-fitting monikers for the field as a whole. The present research shows that there are, in fact, instances where inner music is being consciously controlled—inner music is clearly more than just involuntary musical imagery. So, if researchers have been assuming that musical imagery is involuntary, have they actually been capturing *only* instances of involuntary musical imagery? This seems unlikely. No research in the musical imagery to date has asked whether people were in control of their inner music, let alone separately considered the initiation and maintenance of these episodes. Assuming that you are specifically measuring involuntary musical imagery just because it is the terminology the field has adopted doesn't make sense—it begs the question, what about *voluntary* musical imagery? This aspect of inner music has been ignored, likely in part due to the confining nature of the terminology favored by the field. To expand the scope of future work beyond earworms, the terms for the field also must be expanded. Using *musical imagery* or *inner music* as descriptors accomplish this—like visual imagery or auditory imagery, *musical imagery* and *inner music* provide an overarching umbrella that different experiences or terms, such as involuntary musical imagery or earworms, fall under.

Similar adjustments must be made to the language used in the measurement of musical imagery. Although involuntary musical imagery is the favored term for manuscripts, earworm is frequently used in self-report measures (e.g., "When you were experiencing the earworm, did you feel irritated?" Beaman & Williams, 2010; "Earworms help me when I'm trying to get things done," Floridou et al., 2015). *Earworm* is a term used colloquially and carries an idea of a specific experience for many people—

if we are purportedly measuring musical imagery in general or even the more specific involuntary musical imagery, asking participants to answer questions about their earworms may not be capturing the types of experiences we as researchers are hoping to learn more about. What *earworm* means to participants may be completely different from our conceptualization of involuntary musical imagery. *Earworm* is a loaded term that is inappropriate for use in self-report measures. Using more general terms or phrases in our measures (e.g. "The music in my mind…"; "The song in my head…") still captures earworm experiences but is neutral and does not imply a specific type of experience. This will allow for future work to actually assess the construct of musical imagery rather than encountering the bias that using the term earworm may introduce.

The inclusion of mental control. The present research clearly demonstrates that exerting control over musical imagery does occur and that this can no longer be ignored in future research. Although related, initiation and maintenance are distinct kinds of control that can be used to influence how inner music is experienced. Related fields, such as mind wandering (see Seli et al., 2016), have recognized the distinction between controlled and uncontrolled mental imagery experiences, and the musical imagery field should begin to investigate these differences. In the present study, we assessed both actual instances of controlling one's inner music—whether the episode was initiated and if someone was actively trying to keep the internal music playing—and perceived control over the experience, such as feeling that the music is under control and that it could be stopped if desired. Control is not just a switch that has been stuck in the "off" position since musical imagery research picked up a decade ago. There are subtle ways that

control can be used in musical imagery, and it deserves attention instead of being brushed aside and assumed to not exist.

Future work should look at new and different ways control can be used in inner music and continue to investigate the components of mental control introduced here—initiation and maintenance. I studied instances of control during naturally occurring episodes, but there are others ways that we can learn about people's abilities to exert control over these internal experiences. For example, using ESM, we could ask people who are hearing inner music when signaled and to perform specific controlled manipulations (e.g., speed up the tempo, fast forward to another point in the song, change songs completely). For people who are not hearing inner music when signaled, they could be asked to initiate an episode of musical imagery and perform similar manipulations to the initiated music. This type of project may also help to clarify the somewhat puzzling relationships found between the BAIS control subscale and the ESM control items.

Additional dimensions. The present work demonstrated that a dimensional approach to musical imagery is fruitful. The dimensions detailed here, however, should not be considered the only dimensions of musical imagery that exist. I believe that the five dimensions examined are probably the most salient and variable aspects of musical imagery in normal populations, but there is room for further development. For example, moving along to inner music was considered to be a component of the overall vividness of inner music, but should physical responses to inner music be its own dimension? Movement was only moderately related to the other vividness items, so should it be a component of the broader vividness dimension?

Additionally, some interesting dimensions were not considered in this study, such as whether someone believes they have agency in the experience or finds it alien and intrusive. For example, when people hear thoughts in their head, they nearly always feel that the thoughts originated from themselves (Stephens & Graham, 2000). People feel like they are the agents that generate and own their own thoughts. In some instances, however, someone may hear thoughts in his or her head but believe that they are someone else's thoughts. People may consider these to be intrusive, inserted, or alien thoughts. Similar "me vs. not me" beliefs might exist for musical imagery. People typically feel a measure of agency in these episodes, but some people might occasionally feel as though the music was inserted into their mind. Agency is a separate issue from control. Someone may believe that an involuntarily initiated episode of inner music did originate from their own mind and experience it as a "me" quality of consciousness, whereas someone else may think that this music was inserted into their mind from a foreign source and experience it as a "not me" quality of consciousness. Whether or not it is consciously controlled is a separate matter. It's probably very uncommon to believe that inner music has been inserted, but it's an interesting dimension nevertheless. One wouldn't expect to observe variability in it in normal populations, but it deserves attention in future work.

Conclusion

Musical imagery is more than a select few experiences—it's incredibly variable and diverse. The present research demonstrates that there are several shortcomings with how inner music has been studied in the past, but there are ways to move towards a more theoretically grounded field of musical imagery. A dimensional approach, used in several

other fields, seems to be a promising starting point—with this framework, we can assess the qualities of musical imagery rather than using a one-size-fits-all assumption about what these experiences look like. We especially need to consider the role of mental control in shaping how musical imagery episodes unfold—something that has been ignored in past work. The present research is just the beginning—there are many avenues to explore in future research if we take a dimensional approach to inner music.

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APPENDIX A

TABLES

Table 1

Correlations and Descriptive Statistics of Musical Imagery Items.

	M (range)	*SD*	1	2	3	4	5	6	7
M (range)			.25 (0, 1)	5.23 (1, 7)	6.00 (4, 7)	.72 (0, 1)	4.74 (1, 7)	4.74 (1, 7)	3.33 (1, 7)
SD			.43	1.56	1.00	.45	1.69	1.78	2.17
1. Frequency	.25 (.02, .86)	.17	---	---	---	---	---	---	---
2. Enjoy	5.22 (3.29, 7.01)	.86	-.08	---	.22	-.09	.28	.29	.24
3. No Music (*R*)	5.99 (4.99, 6.96)	.42	-.18	.74	---	-.02	.18	.18	.09
4. Repetitive	.72 (.25, 1.01)	.17	.10	.01	.02	---	-.12	-.14	-.12
5. Lifelike	4.64 (1.99, 6.80)	1.08	.03	.52	.33	.19	---	.60	.25
6. Listen	4.67 (2.13, 6.73)	1.02	.01	.44	.21	.17	.90	---	.30
7. Movement	3.50 (1.27, 6.22)	1.10	-.33	.41	.25	.02	.48	.44	---
8. Purpose	3.22 (.92, 6.26)	1.30	-.23	.25	-.04	-.27	.23	.20	.30
9. Start	3.29 (1.00, 6.47)	1.34	-.26	.27	-.02	-.30	.24	.20	.35

10. Stop	3.96 (1.04, 6.42)	1.27	-.35	.38	.23	-.35	.22	.18	.28
11. Keep Playing	3.35 (1.20, 6.52)	1.17	-.26	.47	.14	-.33	.38	.37	.58
12. Control	4.17 (1.27, 7.00)	1.30	-.36	.42	.21	-.34	.26	.22	.26
13. Episode Length	.93 (.13, 2.19)	.39	.20	.16	.06	.09	.34	.31	.35
14. Section Length	1.48 (.40, 3.38)	.65	.22	.39	.21	-.23	.43	.37	.43

	M (range)	*SD*	8	9	10	11	12	13	14
M (range)			2.89 (1, 7)	2.94 (1, 7)	3.58 (1, 7)	3.07 (1, 7)	3.77 (1, 7)	1.01 (0, 3)	1.59 (0,4)
SD			2.01	2.02	1.97	1.90	1.95	.83	1.19
1. Frequency	.25 (.02, .86)	.17	---	---	---	---	---	---	---
2. Enjoy	5.22 (3.29, 7.01)	.86	.19	.22	.16	.25	.20	.17	.22
3. No Music (*R*)	5.99 (4.99, 6.96)	.42	.06	.11	.02s	.12	.14	.10	.11
4. Repetitive	.72 (.25, 1.01)	.17	-.13	-.15	-.15	-.14	-.11	.03	-.26
5. Lifelike	4.64 (1.99, 6.80)	1.08	.19	.21	.09	.27	.15	.14	.24
6. Listen	4.67 (2.13, 6.73)	1.02	.21	.25	.12	.28	.17	.16	.29

7. Movement	3.50 (1.27, 6.22)	1.10	.24	.27	.06	.31	.17	.13	.21
8. Purpose	3.22 (.92, 6.26)	1.30	---	.79	.28	.48	.37	.13	.28
9. Start	3.29 (1.00, 6.47)	1.34	.98	---	.26	.51	.38	.16	.29
10. Stop	3.96 (1.04, 6.42)	1.27	.61	.65	---	.24	.49	-.04	.09
11. Keep Playing	3.35 (1.20, 6.52)	1.17	.70	.78	.67	---	.40	.17	.26
12. Control	4.17 (1.27, 7.00)	1.30	.70	.71	.94	.71	---	.07	.15
13. Episode Length	.93 (.13, 2.19)	.39	-.16	-.09	-.17	.10	-.15	---	.35
14. Section Length	1.48 (.40, 3.38)	.65	.14	.20	.25	.45	.26	.58	---

Note. Within-person descriptive statistics (row) and correlations are presented above the diagonal; between-person descriptive statistics (column) and correlations are below the diagonal. Within-person correlations between the frequency and other experience items is undefined due to survey branching. For the between level, the estimated Min/Max values could exceed the nominal scale values (1 to 7) because of the estimation method used by Mplus.

Table 2

Within-Person Correlations Between Musical Imagery and Mood and Environment Items.

	Happy	Relaxed	Bored	Sad	Irritated	Excited	Tired	Stressful Situation	Pleasant Situation	Env. Music	Alone
Frequency	.03	.03	.02	-.03	-.05	.03	.03	-.03	.00	-.03	-.09
Enjoy	.34	.24	-.14	-.08	-.18	.20	-.08	-.07	.19	.10	.02
No Music (*R*)	.22	.13	-.10	-.08	-.09	.07	-.07	-.06	.09	.07	.03
Repetitive	-.04	-.03	-.01	-.03	-.01	-.05	.03	-.02	-.03	-.27	.02
Lifelike	.21	.16	-.02	-.07	-.03	.16	-.11	-.06	.10	.15	-.04
Listen	.23	.15	-.07	-.12	-.08	.19	-.10	-.05	.09	.20	-.02
Movement	.20	.10	-.02	-.13	-.07	.19	-.09	.02	.13	.19	.08
Purpose	.24	.20	-.09	-.08	-.08	.18	-.09	-.01	.16	.20	.00
Start	.21	.18	-.09	-.03	-.06	.18	-.10	-.01	.14	.22	-.01
Stop	.17	.15	-.02	-.09	-.05	.11	-.04	-.01	.12	.14	-.06
Keep Playing	.23	.16	-.09	-.03	-.07	.22	-.08	-.01	.12	.21	.00
Control	.22	.16	-.03	-.07	-.05	.16	-.05	.00	.11	.09	-.03
Episode Length	.05	.04	-.09	.03	.00	.05	.00	.05	.05	.03	.00
Section Length	.12	.09	-.13	-.06	-.08	.10	-.11	-.02	.10	.24	.01

Note. The presence of environmental music was coded 1 = Yes (there was music) and 0 = No (there was not music). The Alone variable was coded 0 = Alone, by myself, 1 = With other people, but not interacting with them, and 2 = Interacting with other people.

Table 3

Correlations and Descriptive Statistics of Mood and Environment Items.

	M (Range)	*SD*	1	2	3	4	5	6
M (Range)			4.95 (1, 7)	4.65 (1, 7)	2.77 (1, 7)	2.22 (1, 7)	2.61 (1, 7)	3.24 (1, 7)
SD			1.71	1.76	1.77	1.58	1.87	1.88
1. Happy	4.95 (2.14, 7.03)	.99	---	.56	-.23	-.40	-.40	.37
2. Relaxed	4.69 (1.85, 6.83)	.89	.84	---	.20	-.26	-.37	.29
3. Bored	2.91 (1.11, 6.01)	.95	-.19	-.06	---	.22	.25	-.11
4. Sad	2.27 (.94, 4.30)	.88	-.46	-.46	.50	---	.43	-.11
5. Irritated	2.65 (1.02, 5.06)	.99	-.36	-.32	.65	.77	---	-.18
6. Excited	3.67 (1.21, 6.64)	1.12	.48	.45	.32	.16	.18	---
7. Tired	4.05 (1.47, 6.60)	1.02	.06	.00	.42	.31	.34	.21
8. Stressful Situation	2.74 (1.10, 5.72)	.97	-.36	-.43	.48	.85	.78	.22
9. Pleasant Situation	4.31 (1.45, 6.55)	.90	.85	.86	-.08	-.36	-.30	.51
10. Env. Music	.25 (.04, .57)	.10	.25	.06	-.10	-.15	-.20	.03
11. Alone	.90 (.07, 1.62)	.34	.21	.08	-.16	-.21	-.20	.17

	M (Range)	*SD*	7	8	9	10	11
M (Range)			4.01 (1, 7)	2.69 (1, 7)	4.28 (1, 7)	.25 (0, 1)	.92 (0, 2)
SD			1.99	1.83	1.81	.43	.85
1. Happy	4.95 (2.14, 7.03)	.99	-.16	-.36	.50	.13	.11
2. Relaxed	4.69 (1.85, 6.83)	.89	-.10	-.40	.51	.09	.02
3. Bored	2.91 (1.11, 6.01)	.95	.23	.18	-.19	-.11	-.04
4. Sad	2.27 (.94, 4.30)	.88	.19	.42	-.26	-.06	-.04
5. Irritated	2.65 (1.02, 5.06)	.99	.21	.49	-.34	-.07	.00
6. Excited	3.67 (1.21, 6.64)	1.12	-.18	-.15	.38	.12	.14
7. Tired	4.05 (1.47, 6.60)	1.02	---	.16	-.13	-.08	-.07
8. Stressful Situation	2.74 (1.10, 5.72)	.97	.34	---	-.40	-.03	-.03
9. Pleasant Situation	4.31 (1.45, 6.55)	.90	-.02	-.39	---	.08	.09
10. Env. Music	.25 (.04, .57)	.10	.16	-.16	.11	---	.07
11. Alone	.90 (.07, 1.62)	.34	.00	-.05	.08	.11	---

Note. Within-person correlations and descriptive statistics are reported above the diagonal and between person correlations and descriptive statistics below the diagonal. The presence of environmental music was coded 1 = Yes (there was music) and 0 = No (there was not music). The Alone variable was coded 0 = Alone, by myself, 1 = With other people, but not interacting with them, and 2 = Interacting with other people.

Table 4

Between-Person Correlations Between Musical Imagery and Mood and Environment Items.

	Happy	Relaxed	Bored	Sad	Irritated	Excited	Tired	Stressful Situation	Pleasant Situation	Env. Music	Alone
Frequency	.01	-.03	-.08	-.02	-.09	-.03	-.05	-.04	.01	.22	-.10
Enjoy	.55	.52	.01	-.09	.03	.33	.19	-.01	.47	.22	-.01
No Music (*R*)	.33	.46	-.33	-.38	-.34	-.04	.04	-.39	.30	.06	-.01
Repetitive	.05	.06	.13	.05	.17	-.02	.01	.02	.09	-.04	-.13
Lifelike	.42	.37	-.05	-.06	.04	.21	.19	-.06	.38	.11	.02
Listen	.39	.28	-.03	-.02	.04	.07	.28	-.03	.30	.07	-.12
Movement	.26	.32	.28	.08	.22	.27	.31	.15	.29	-.06	.15
Purpose	.05	.10	.31	.27	.28	.53	.07	.26	.09	-.25	-.06
Start	.03	.10	.37	.28	.32	.56	.08	.28	.09	-.25	-.05
Stop	.02	.18	.26	.06	.12	.29	-.12	.05	.13	-.04	.00
Keep Playing	.15	.19	.40	.27	.28	.48	.12	.24	.23	-.09	-.06
Control	.09	.16	.22	.15	.15	.37	-.08	.10	.16	-.01	-.02
Episode Length	.14	.15	.03	.02	.12	-.05	.25	-.08	.27	.02	.02
Section Length	.16	.07	-.01	-.03	.00	.12	.05	.02	.18	.07	.18

Note. $N = 132$. The presence of environmental music was coded 1 = Yes (there was music) and 0 = No (there was not music). The Alone variable was coded 0 = Alone, by myself, 1 = With other people, but not interacting with them, and 2 = Interacting with other people.

Table 5

Correlations Between Musical Imagery Items and Personality Factors and Facets.

	M	*SD*	Reliability (α)	Frequency	Enjoy	No Music (*R*)	Repetitive	Lifelike	Listen	Movement
Neuroticism	**3.00**	**.48**	**.92**	**.18**	**-.19**	**-.24**	**.12**	**-.20**	**-.23**	**-.14**
Anxiety	3.29	.61	.71	-.01	-.09	-.13	.06	-.10	-.11	-.12
Angry Hostility	2.91	.59	.67	.12	-.16	-.22	-.07	-.23	-.26	-.11
Depression	3.16	.78	.83	.23	-.18	-.27	.01	-.19	-.20	-.07
Self-Consciousness	2.97	.68	.76	.13	-.18	-.18	.11	-.23	-.28	-.20
Impulsiveness	3.05	.54	.59	.22	-.07	-.16	.09	-.12	-.08	.05
Vulnerability	2.63	.59	.76	.10	-.17	-.25	.17	-.04	-.02	.02
Extraversion	**3.37**	**.43**	**.89**	**.16**	**.24**	**.20**	**-.14**	**.22**	**.20**	**.20**
Warmth	3.74	.59	.77	.13	.21	.22	.11	.24	.23	.18
Gregariousness	3.08	.68	.77	.06	.17	.19	-.04	.09	.07	.24
Assertiveness	3.08	.67	.76	.07	.08	.02	-.27	.11	.11	.10
Activity	3.15	.55	.64	.22	.21	.06	.00	.22	.15	.04
Excitement-Seeking	3.57	.56	.56	.16	.17	.23	-.10	.12	.12	.09
Positive Emotions	3.59	.57	.70	.07	.23	.23	.01	.24	.27	.22
Openness to Experience	**3.48**	**.39**	**.88**	**.43**	**-.11**	**.01**	**.10**	**.12**	**.04**	**-.22**
Fantasy	3.46	.65	.78	.32	-.01	.18	.24	.14	.10	.00

Aesthetics	3.48	.73	.80	.41	-.11	-.11	-.22	-.07	-.14	-.23
Feelings	3.79	.53	.67	.32	.01	.00	.04	.12	.12	-.09
Actions	2.98	.44	.52	.14	-.21	-.11	.11	.00	.11	-.17
Ideas	3.49	.63	.76	.27	-.14	-.02	-.07	.11	.00	-.20
Values	3.70	.54	.6	.26	-.08	.03	.11	.11	.00	-.23
Agreeableness	**3.40**	**.33**	**.84**	**.11**	**.03**	**.18**	**.11**	**.06**	**.06**	**-.06**
Trust	3.01	.62	.77	.16	.09	.10	.02	.03	.01	-.04
Straightforwardness	3.39	.61	.71	.01	-.08	.09	.05	-.02	.12	-.12
Altruism	3.94	.49	.67	.04	.13	.33	.12	.11	.08	.19
Compliance	2.82	.54	.65	.03	.07	.03	.18	.11	.11	.05
Modesty	3.44	.58	.70	.11	-.06	.12	.02	.06	.07	-.13
Tender-Mindedness	3.81	.45	.58	.05	.03	.23	.15	.01	-.06	-.06
Conscientiousness	**3.54**	**.43**	**.92**	**-.14**	**.21**	**.28**	**-.11**	**.21**	**.20**	**.07**
Competence	3.61	.48	.63	-.15	.06	.19	-.04	.08	.14	.01
Order	3.39	.68	.80	-.09	.10	.13	-.20	.08	.07	.05
Dutifulness	3.78	.42	.53	-.05	.24	.28	-.13	.28	.33	.11
Achievement Striving	3.79	.55	.74	-.02	.21	.26	-.05	.21	.22	.07
Self-Discipline	3.47	.62	.78	-.14	.17	.33	-.19	.18	.18	-.06
Deliberation	3.22	.61	.78	-.17	.13	.17	-.03	.12	.09	-.08

	M	*SD*	Reliability (α)	Purpose	Start	Stop	Keep Playing	Control	Episode Length	Section Length
Neuroticism	**3.00**	**.48**	**.92**	**-.18**	**-.18**	**-.32**	**.19**	**-.30**	**.16**	**.03**
Anxiety	3.29	.61	.71	-.16	-.22	-.21	-.16	-.19	.04	-.09
Angry Hostility	2.91	.59	.67	-.09	-.09	-.25	-.17	-.26	.11	.08
Depression	3.16	.78	.83	-.06	-.05	-.15	-.17	-.19	.07	-.08
Self-Consciousness	2.97	.68	.76	-.19	-.16	-.25	-.18	-.24	.07	-.07
Impulsiveness	3.05	.54	.59	-.10	-.13	-.22	-.09	-.25	.03	.07
Vulnerability	2.63	.59	.76	-.21	-.17	-.39	-.09	-.34	.23	.05
Extraversion	**3.37**	**.43**	**.89**	**.04**	**.04**	**.07**	**.09**	**.10**	**.14**	**.28**
Warmth	3.74	.59	.77	-.06	-.03	.01	.10	.05	.24	.21
Gregariousness	3.08	.68	.77	.03	.08	.10	.20	.14	.02	.16
Assertiveness	3.08	.67	.76	.16	.13	.17	.07	.19	.13	.23
Activity	3.15	.55	.64	.10	.11	-.01	.08	.00	.06	.21
Excitement-Seeking	3.57	.56	.56	-.02	-.03	.03	.01	.02	-.04	.01
Positive Emotions	3.59	.57	.70	-.09	-.10	-.07	.05	-.06	.19	.26
Openness to Experience	**3.48**	**.39**	**.88**	**-.39**	**-.44**	**-.34**	**-.44**	**-.42**	**.02**	**.07**
Fantasy	3.46	.65	.78	-.36	-.36	-.30	-.19	-.42	.02	.05
Aesthetics	3.48	.73	.80	-.37	-.40	-.19	-.38	-.24	-.13	.05
Feelings	3.79	.53	.67	-.24	-.25	-.16	-.25	-.19	.06	.21

Actions	2.98	.44	.52	-.17	-.20	-.19	-.31	-.21	-.23	-.22
Ideas	3.49	.63	.76	-.18	-.20	-.14	-.32	-.20	.05	.12
Values	3.70	.54	.6	-.20	-.26	-.26	-.35	-.25	.04	.11
Agreeableness	**3.40**	**.33**	**.84**	**-.22**	**-.21**	**-.16**	**-.10**	**-.06**	**.16**	**.08**
Trust	3.01	.62	.77	-.09	-.07	-.01	.04	.02	.04	.12
Straightforwardness	3.39	.61	.71	-.12	-.12	-.11	-.11	-.03	.10	.07
Altruism	3.94	.49	.67	-.13	-.14	-.02	.02	.06	.11	.16
Compliance	2.82	.54	.65	-.07	-.02	-.14	.05	-.03	.24	.01
Modesty	3.44	.58	.70	-.15	-.16	-.21	-.08	-.15	.11	.05
Tender-Mindedness	3.81	.45	.58	-.22	-.25	-.01	-.24	-.05	-.09	-.11
Conscientiousness	**3.54**	**.43**	**.92**	**.12**	**.08**	**.23**	**.12**	**.28**	**-.03**	**-.07**
Competence	3.61	.48	.63	-.03	-.09	.13	-.04	.13	-.05	-.14
Order	3.39	.68	.80	.23	.23	.27	.19	.28	.00	.15
Dutifulness	3.78	.42	.53	.03	-.02	.12	.05	.14	.15	-.03
Achievement Striving	3.79	.55	.74	.04	-.02	.11	.04	.12	-.08	-.07
Self-Discipline	3.47	.62	.78	.12	.10	.29	.13	.35	-.09	.01
Deliberation	3.22	.61	.78	.16	.09	.16	.16	.28	-.04	-.16

Note. $N = 132$.

Table 6

NEO Personality Factors Predicting Inner Music ESM Items.

	Neuroticism	Extraversion	Openness to Experience	Agreeableness	Conscientiousness
Frequency	β = .12 (.10) [-.09, .32]	β = .20** (.08) [.05, .36]	β = .39*** (.08) [.24, .55]	β = .04 (.07) [-.11, .18]	β = -.10 (.09) [-.27, .08]
Enjoyment	β = -.07 (.12) [-.30, .17]	β = .19 (.11) [-.03, .41]	β = -.10 (.10) [-.30, .09]	β = .00 (.10) [-.20, .19]	β = .11 (.13) [-.14, .35]
No Music (*R*)	β = -.08 (.12) [-.31, .14]	β = .09 (.11) [-.12, .30]	β = .02 (.10) [-.20, .23]	β = .11 (.10) [-.09, .30]	β = .20 (.11) [-.02, .42]
Repetitiveness	β = .07 (.12) [-.16, .30]	β = -.14 (.13) [-.38, .11]	β = .07 (.11) [-.15, .28]	β = .13 (.12) [-.09, .36]	β = -.04 (.11) [-.27, .18]
Lifelike	β = -.11 (.10) [-.31, .09]	β = .15 (.10) [-.04, .33]	β = .12 (.10) [-.07, .32]	β = .01 (.11) [-.20, .22]	β = .13 (.10) [-.07, .32]
Listening	β = -.13 (.11) [-.35, .09]	β = .13 (.11) [-.09, .34]	β = .04 (.11) [-.16, .25]	β = .00 (.12) [-.23, .12]	β = .09 (.11) [-.13, .30]
Movement	β = -.06 (.10) [-.25, .14]	β = .21* (.11) [.01, .42]	β = -.22* (.10) [-.41, -.02]	β = -.05 (.09) [-.24, .13]	β = -.01 (.12) [-.24, .23]
Purpose	β = -.06 (.10) [-.26, .14]	β = .04 (.10) [-.15, .23]	β = -.33*** (.10) [-.52, -.14]	β = .17* (.09) [-.34, .00]	β = .06 (.11) [-.17, .28]
Start	β = -.07 (.10) [-.27, .13]	β = .06 (.10) [-.14, .26]	β = -.38*** (.09) [-.56, -.20]	β = -.16 (.09) [-.33, .01]	β = .01 (.11) [-.19, .22]
Stop	β = -.21 (.11) [-.43, .01]	β = .03 (.11) [-.19, .25]	β = -.28** (.09) [-.46, -.09]	β = -.16 (.09) [-.33, .00]	β = .11 (.12) [-.12, .34]
Keep Playing	β = -.05 (.11) [-.26, .16]	β = .08 (.10) [-.11, .28]	β = -.42*** (.10) [-.61, -.23]	β = -.09 (.09) [-.26, .09]	β = .03 (.11) [-.20, .25]
Control	β = -.11 (.11) [-.22, .10]	β = .04 (.10) [-.16, .24]	β = -.36*** (.09) [-.54, -.17]	β = -.06 (.08) [-.22, .10]	β = .15 (.12) [-.08, .39]
Episode Length	β = .24* (.10)	β = .17 (.10)	β = -.06 (.11)	β = .17 (.10)	β = .01 (.11)

	[.05, .44]	[-.03, .37]	[-.27, .15]	[-.03, .36]	[-.22, .23]
Section Length	β = .08 (.10)	β = .30** (.11)	β = .00 (.11)	β = .04 (.10)	β = -.11 (.09)
	[-.10, .27]	[.09, .51]	[-.22, .21]	[-.15, .23]	[-.28, .07]

Note. $N = 132$. All regression coefficients are standardized, standard errors are presented in parentheses, and 95% confidence intervals are in square brackets. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 7

Correlations Among BAIS and GMSI Subscales.

	M (range)	*SD*	Reliability (α)	1	2	3	4	5	6	7	8
1. BAIS Vividness	4.44 (1.43, 6.71)	1.02	.83	---	.61	.18	.05	.21	.24	.20	.18
2. BAIS Control	5.01 (1.71, 6.86)	.94	.82		---	.28	.22	.34	.36	.28	.33
3. Perceptual Abilities	47.06 (25.00, 63.00)	7.19	.77			---	.68	.66	.67	.67	.81
4. Singing Abilities	30.31 (11.00, 47.00)	7.52	.79				---	.45	.57	.56	.82
5. Emotions	32.72 (22.00, 42.00)	4.54	.66					---	.68	.51	.64
6. Active Engagement	39.18 (11.00, 63.00)	10.85	.87						---	.73	.86
7. Musical Training	23.35 (7.00, 49.00)	11.95	.92							---	.88
8. General Sophistication	76.53 (22.00, 121.00)	20.27	.92								---

Note. $N = 132$.

Table 8

Correlations Between Inner Music Items and BAIS and GMSI Subscales.

	BAIS Vividness	BAIS Control	Perceptual Abilities	Singing Abilities	Emotions	Active Engagement	Musical Training	General Sophistication
Frequency	-.03	.06	.34	.34	.37	.42	.48	.49
Enjoyment	.16	.11	.15	.01	.04	.05	.00	.03
No Music (*R*)	.07	.22	.12	.01	.10	-.01	-.15	-.06
Repetitiveness	.13	.04	-.03	-.05	-.07	-.14	-.11	-.12
Lifelikeness	.42	.22	.16	-.01	.20	.15	.06	.06
Listening	.48	.20	.10	-.01	.12	.10	.04	.02
Movement	.18	-.01	-.06	-.08	-.13	-.06	-.16	-.14
Purpose	.22	-.11	-.16	-.14	-.22	-.19	-.17	-.17
Start	.18	-.05	-.14	-.10	-.20	-.16	-.16	-.14
Stop	.02	-.07	-.07	-.13	-.17	-.25	-.28	-.23
Keep Playing	.21	-.07	-.16	-.21	-.15	-.12	-.16	-.19
Control	.07	-.03	-.09	-.15	-.18	-.27	-.24	-.23
Episode Length	.19	.19	.20	.09	.24	.24	.28	.24
Section Length	.10	.10	.10	.11	.11.	25	.19	.21

Note. $N = 132$.

Table 9

Inner Music Items Predicted by BAIS and GMSI Subscales.

	BAIS Vividness	BAIS Control	Perceptual Abilities	Singing Abilities	Emotions	Active Engagement	Musical Training
Frequency	β = -.12 (.13) [-.37, .12]	β = -.06 (.13) [-.31, .19]	β = -.14 (.14) [-.41, .13]	β = .10 (.11) [-.11, .31]	β = .22 (.12) [-.02, .46]	β = .08 (.13) [-.19, .34]	β = .39** (.13) [.14, .64]
Enjoyment	β = .15 (.14) [-.12, .42]	β = .00 (.14) [-.28, .28]	β = .34 (.19) [-.02, .71]	β = -.11 (.14) [-.38, .16]	β = -.12 (.16) [-.43, .19]	β = .02 (.20) [-.37, .41]	β = -.14 (.16) [-.46, .18]
No Music (*R*)	β = -.08 (.14) [-.34, .19]	β = .29* (.13) [.03, .55]	β = .38 (.20) [-.02, .78]	β = -.06 (.14) [-.33, .21]	β = .02 (.16) [-.43, .19]	β = -.03 (.19) [-.40, .35]	β = -.39** (.15) [-.69, -.10]
Repetitive	β = .18 (.15) [-.11, .48]	β = -.02 (.15) [-.31, .27]	β = .12 (.23) [-.33, .58]	β = .05 (.17) [-.28, .37]	β = -.02 (.17) [-.36, .32]	β = -.18 (.22) [-.61, .26]	β = -.10 (.18) [-.45, .24]
Lifelike	β =.41*** (.12) [.17, .65]	β = -.06 (.12) [-.30, .17]	β = .14 (.16) [-.16, .45]	β = -.11 (.12) [-.34, .12]	β = .11 (.14) [-.17, .39]	β = .04 (.19) [-.33, .41]	β = -.10 (.16) [-.42, .21]
Listening	β = .51*** (.12) [.28, .75]	β = -.14 (.12) [-.38, .09]	β = .12 (.14) [-.16, .40]	β = -.05 (.13) [-.30, .20]	β = .01 (.14) [-.26, .29]	β = .07 (.20) [-.33, .46]	β = -.13 (.15) [-.42, .21]
Movement	β = .28* (.13) [.04, .53]	β = -.13 (.14) [-.40, .14]	β = .15 (.17) [-.19, .49]	β = .01 (.16) [-.30, .33]	β = -.19 (.16) [-.50, .13]	β = .17 (.21) [-.24, .57]	β = -.31 (.17) [-.65, .03]
Purpose	β = .44*** (.10) [.25, .64]	β = -.27 (.09) [-.45, -.09]	β = -.01 (.15) [-.30, .28]	β =.07 (.13) [-.18, .32]	β = -.16 (.15) [-.46, .15]	β = -.05 (.18) [-.40, .30]	β = -.07 (.15) [-.36, .23]
Start	β = .37*** (.11) [.15, .59]	β = -.17 (.11) [-.38, .04]	β = -.01 (.16) [-.31, .30]	β = .09 (.13) [-.16, .34]	β = -.15 (.16) [-.45, .16]	β = -.06 (.19) [-.42, .31]	β = -.08 (.15) [-.38, .22]
Stop	β = .14 (.13) [-.12, .40]	β = -.03 (.12) [-.27, .21]	β = .32* (.14)	β = -.02 (.13) [-.26, .23]	β = -.09 (.16) [-.39, .22]	β = -.20 (.20)	β = -.29 (.15) [-.59, .01]

			[.05, .60]			[-.58, .19]	
Keep Playing	β = .43*** (.12) [.20, .67]	β = -.27* (.13) [-.52, -.01]	β = -.04 (.15) [-.33, .24]	β = -.07 (.14) [-.34, .20]	β = -.08 (.16) [-.40, .24]	β =.03 (.20) [-.37, .43]	β = -.07 (.17) [-.39, .26]
Control	β = .15 (.13) [-.11, .41]	β = .00 (.11) [-.23, .22]	β = .22 (.14) [-.06, .51]	β = -.01 (.12) [-.24, .22]	β = -.10 (.16) [-.41, .20]	β = -.20 (.18) [-.55, .14]	β = -.19 (.15) [-.49, .11]
Episode Length	β = .12 (.19) [-.25, .48]	β = .05 (.21) [-.36, .46]	β = .01 (.15) [-.28, .30]	β = -.12 (.15) [-.40, .17]	β = .12 (.17) [-.21, .46]	β = -.03 (.19) [-.40, .33]	β = .27 (.17) [-.06, .60]
Section Length	β = .05 (.17) [-.29, .39]	β = .00 (.19) [-.37, .38]	β = -.16 (.15) [-.45, .12]	β = .04 (.13) [-.21, .28]	β = -.08 (.17) [-.40, .25]	β = .26 (.21) [-.15, .66]	β =.13 (.19) [-.24, .50]

Note. $N = 132$. All regression coefficients are standardized, standard errors are presented in parentheses, and 95% confidence intervals are in square brackets. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 10

IMIS Items and Corresponding ESM Items.

Musical Imagery Quality	Retrospective Items	Experience Sampling Items
Frequency	On average, I experience earworms… (*Never, Once a month, Once a week, Several times a week, Several times a day, Almost continuously*).	Right now, are you hearing music in your head? (*No, Yes*)
Episode Length	On average, one earworm episode (a period of time when one particular tune gets stuck) lasts: (*Less than 10 minutes, Between 10 minutes and half an hour, Between half an hour and 1 hour, Between 1 and 3 hours, Longer 3 hours*)	How long has the much been playing in your mind? (*Less than 1 minute, Between 1 and 5 minutes, Between 5 and 30 minutes, Longer than 30 minutes*)
Section Length	On average my earworm (the section of music that is stuck) lasts: (*Less than 5 seconds, Between 5 to 10 seconds, Between 10 to 30 seconds, Between 30 seconds to 1 minute, More than 1 minute*).	How long is the piece of music of music in your mind? (*Less than 5 seconds, Between 5 and 10 seconds, Between 10 and 30 seconds, Between 30 seconds and 1 minute, More than 1 minute*).
Negative Valence	(*Always, Most of the time, Sometimes, Not very often, Never*) I try hard to get rid of my earworms. It worries me when I have an earworm stuck in my head. I find my earworms irritating. The experience of my earworms is unpleasant. I wish I could stop my earworms. When I get an earworm I try to block it.	*(1 – Strongly Disagree to 7 – Strongly Agree)* I enjoy hearing the music in my mind. I would rather not have music in my head right now *(reverse-scored)*.
Movement	(*Always, Most of the time, Sometimes, Not very often, Never*) The rhythms of my earworms match my	*(1 – Strongly Disagree to 7 – Strongly Agree)* My body is responding to the music (feet tapping, head and body moving).

	movements. The way I move is I sync with my earworms. When I get an earworm I move to the beat of the imagined music.	
Personal Reflections	(*Always, Most of the time, Sometimes, Not very often, Never*) My earworms result from unresolved matters. Personal issues trigger my earworms. The content of my earworms mirrors my state of worry or concern.	N/A
Help	(*Always, Most of the time, Sometimes, Not very often, Never*) I find my earworms help me focus on the task that I'm doing. Earworms help me when I'm trying to get things done.	*(1 – Strongly Disagree to 7 – Strongly Agree)* The music in my mind is distracting me from other things.

Table 11

IMIS Correlations with Itself and Inner Music Items.

	IMIS Negative Valence	IMIS Movement	IMIS Personal Reflections	IMIS Help	IMIS Frequency	IMIS Episode Length	IMIS Section Length
M (range)	2.56 (1, 4.43)	3.14 (1, 5)	2.18 (1, 5)	2.79 (1, 5)	3.68 (1, 6)	2. 16 (1, 5)	3.07 (1, 5)
SD	.77	.94	.78	1.04	1.56	1.19	1.03
Reliability (α)	.90	.86	.72	.84	---	---	---
IMIS Negative Valence	1	-.12	.37	-.44	-.12	-.04	-.27
IMIS Movement		1	.07	.38	.34	.09	.11
IMIS Personal Reflections			1	.05	-.08	.04	-.16
IMIS Help				1	.25	.08	.26
IMIS Frequency					1	.32	.24
IMIS Episode Length						1	.25
IMIS Section Length							1
ESM Frequency	-.05	.09	.14	.11	.43	.29	.09
ESM Enjoy	-.24	.16	-.18	.23	.24	.11	.17
ESM No Music (*R*)	-.15	.02	.25	.17	-.03	.15	.11
ESM Movement	-.02	.29	-.11	.15	-.31	-.30	-.06
ESM Distracting	.11	-.09	.23	-.04	.06	.15	.08
ESM Episode Length	.04	-.05	.13	.07	.17	.56	.04
ESM Section Length	-.12	-.23	-.01	-.03	.12	-.04	.11

Note. $N = 132$.

Table 12

Inner Music Items Predicted by IMIS Subscales.

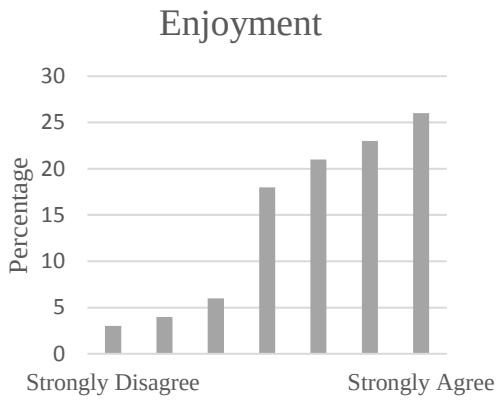
Predictor	Outcome			
	ESM Enjoying	ESM No Music (*R*)	ESM Movement	ESM Distracting
IMIS Negative Valence	β = -.25* (.13) [-.50, .00]	β = -.35** (.14) [-.61, -.08]	β = .00 (.14) [-.27, .27]	β = .15 (.14) [-.12, .43]
IMIS Movement	β = .10 (.10) [-.10, .29]	β = .06 (.13) [-.20, .32]	β = .11 (12) [-.13, .35]	β = .01 (.12) [-.23, .25]
IMIS Personal Reflections	β = -.02 (.12) [-.25, .21]	β = .15 (.13) [-.10, .39]	β = -.02 (.13) [-.28, .24]	β = .12 (.11) [-.10, .34]
IMIS Help	β = .20 (.12) [-.04, .44]	β = .09 (.15) [-.21, .39]	β = .22 (.13) [-.02, .47]	β = -.06 (.12) [-.30, .18]

Note. $N = 132$. All regression coefficients are standardized, standard errors are presented in parentheses, and 95% confidence intervals are in square brackets. * $p < .05$, ** $p < .01$, *** $p < .001$.

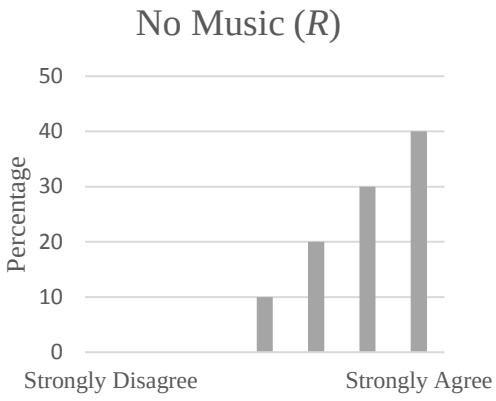
APPENDIX B

FIGURES

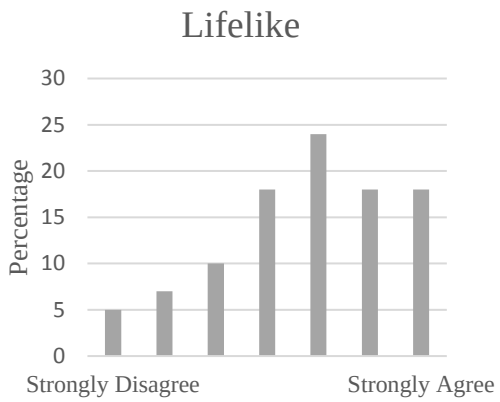
a)



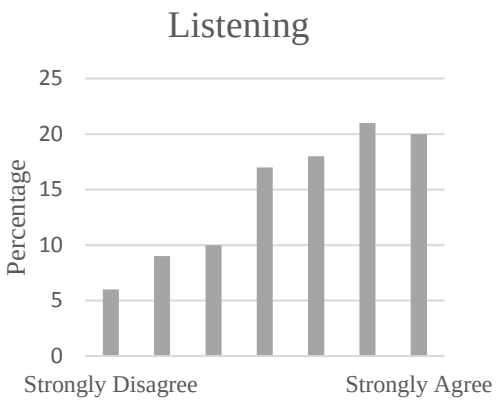
b)



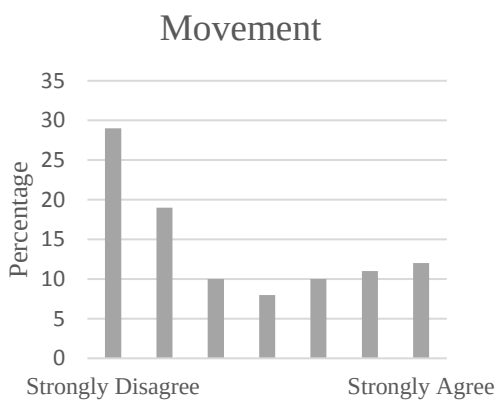
c)



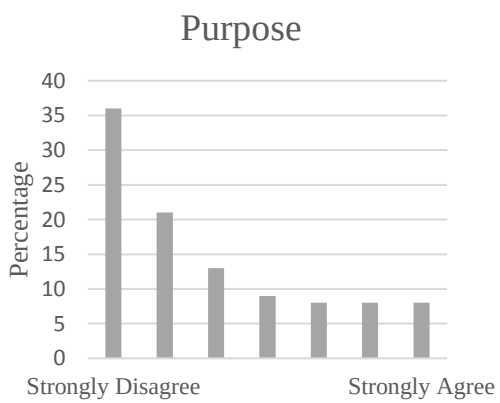
d)



e)



f)



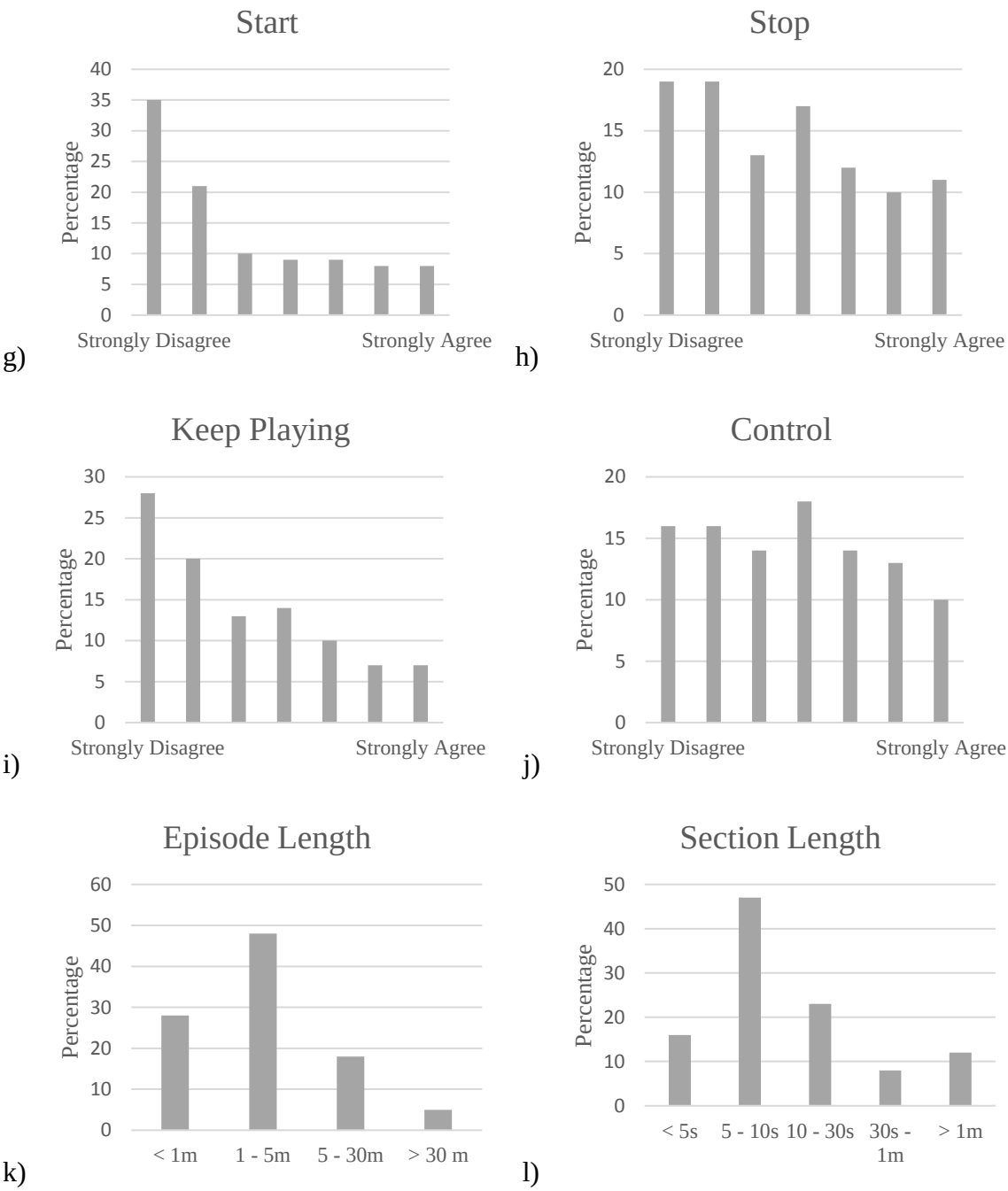


Figure 1

Within-Person Distributions of Musical Imagery Items.

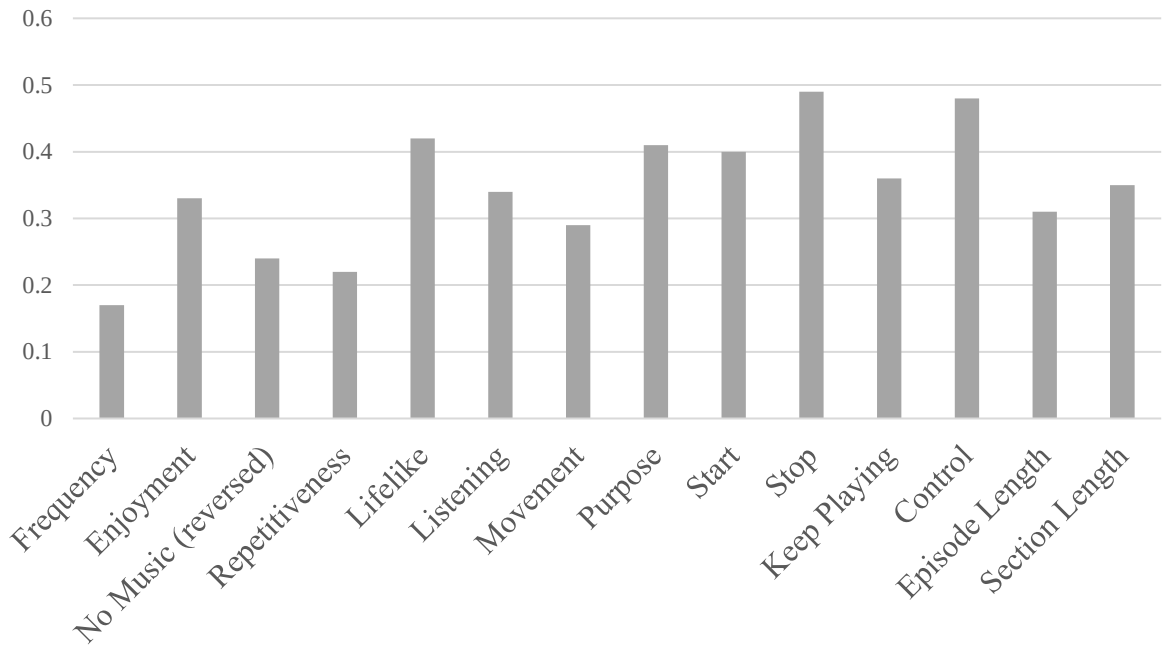
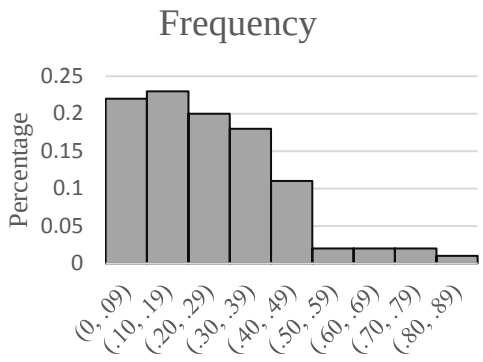


Figure 2

Intraclass Correlations for Musical Imagery Items.

a)


Frequency
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0.2
0.15
0.1
0.05
0
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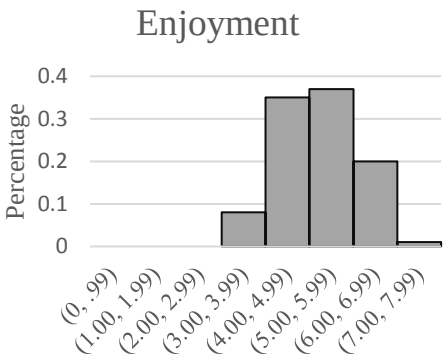
(.10, .19)
(.20, .29)
(.30, .39)
(.40, .49)
(.50, .59)
(.60, .69)
(.70, .79)
(.80, .89)

b)


Enjoyment
Percentage
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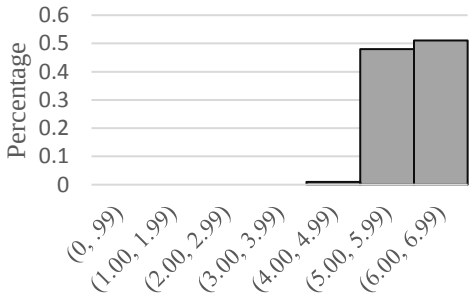
0.3
0.2
0.1
0
(0, .99)
(1.00, 1.99)
(2.00, 2.99)
(3.00, 3.99)
(4.00, 4.99)
(5.00, 5.99)
(6.00, 6.99)
(7.00, 7.99)

c)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(4.00, 4.99)
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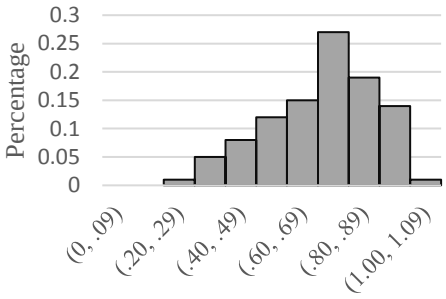
d)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(.60, .69)
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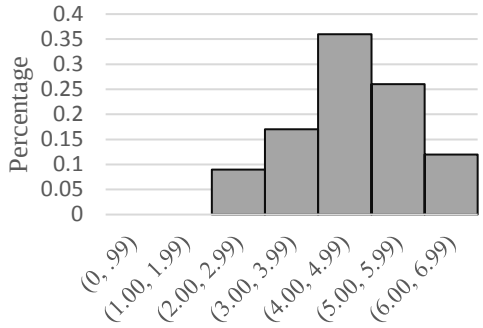
e)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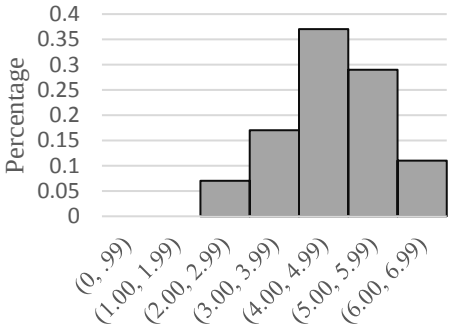
f)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0.05
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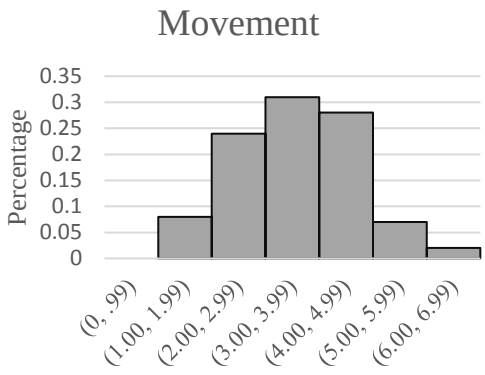
(3.00, 3.99)
(4.00, 4.99)
(5.00, 5.99)
(6.00, 6.99)

g)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Percentage
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0.2
0.15
0.1
0.05
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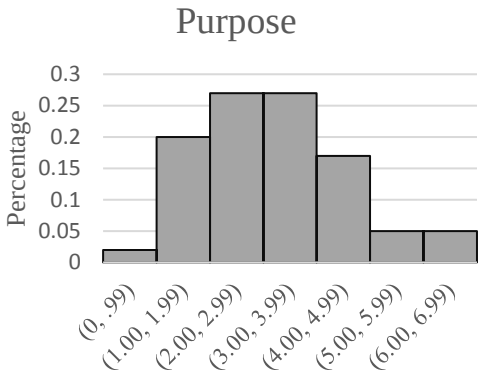
(5.00, 5.99)
(6.00, 6.99)

h)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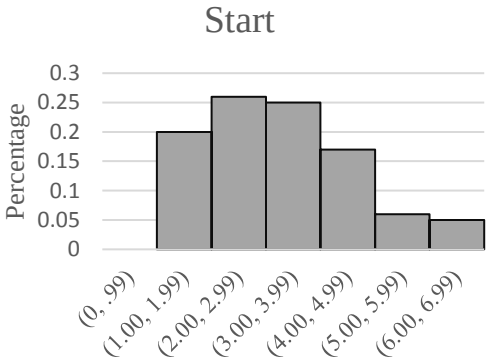
(3.00, 3.99)
(4.00, 4.99)
(5.00, 5.99)
(6.00, 6.99)

i)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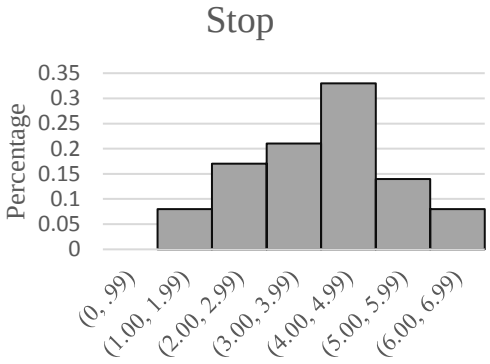
j)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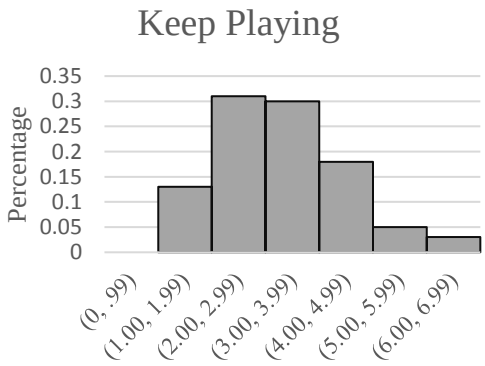
k)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0.15
0.1
0.05
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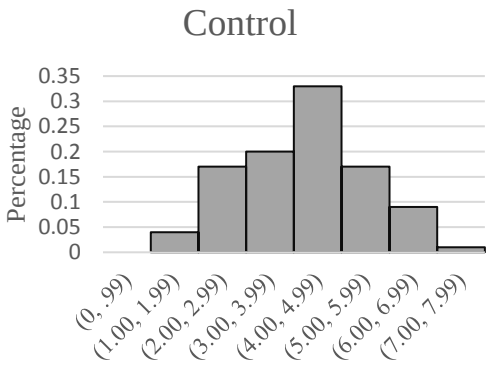
(3.00, 3.99)
(4.00, 4.99)
(5.00, 5.99)
(6.00, 6.99)

l)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0.05
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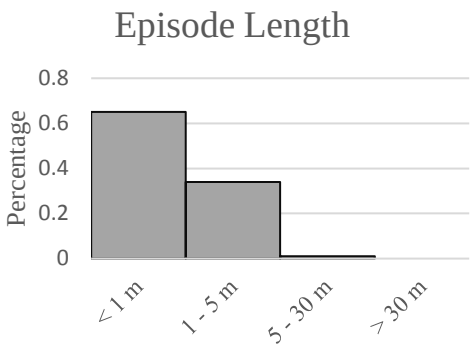
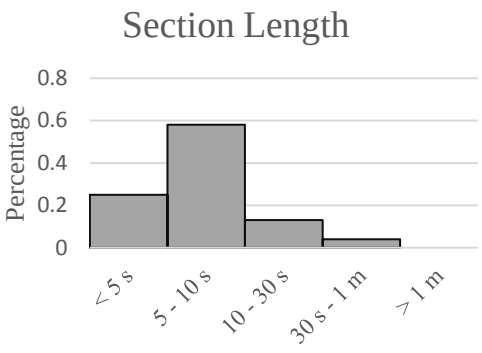


m)



n)

Figure 3

Between-Person Distributions of Musical Imagery Items.

APPENDIX C

GOLDSMITHS MUSICAL SOPHISTICATION INDEX

Please select the most appropriate category:	**1 Completely Disagree**	**2 Strongly Disagree**	**3 Disagree**	**4 Neither Agree nor Disagree**	**5 Agree**	**6 Strongly Agree**	**7 Completely Agree**
I spend a lot of my free time doing music-related activities.	1	2	3	4	5	6	7
I sometimes choose music that can trigger shivers down my spine.	1	2	3	4	5	6	7
I enjoy writing about music, for example on blogs and forums.	1	2	3	4	5	6	7
If somebody starts singing a song I don't know, I can usually join in.	1	2	3	4	5	6	7

I am able to judge whether someone is a good singer or not.	1	2	3	4	5	6	7
I usually know when I'm hearing a song for the first time.	1	2	3	4	5	6	7
I can sing or play music from memory.	1	2	3	4	5	6	7
I'm intrigued by musical styles I'm not familiar with and want to find out more.	1	2	3	4	5	6	7
Pieces of music rarely evoke emotions for me.	1	2	3	4	5	6	7
I am able to hit the right notes when I sing along with a recording.	1	2	3	4	5	6	7

I find it difficult to spot mistakes in a performance of a song even if I know the tune.	1	2	3	4	5	6	7
I can compare and discuss difference between two performances or versions of the same piece of music.	1	2	3	4	5	6	7
I have trouble recognizing a familiar song when played to a different way or by a different performer.	1	2	3	4	5	6	7
I have never been complimented for my talents as a musical performer.	1	2	3	4	5	6	7
I often read or search the Internet for things related to music.	1	2	3	4	5	6	7

I often pick certain music to motivate or excite me.	1	2	3	4	5	6	7
I am not able to sing in harmony when somebody is singing a familiar tune.	1	2	3	4	5	6	7
I can tell when people sing or play out of time with the beat.	1	2	3	4	5	6	7
I am able to identify what is special about a given musical piece.	1	2	3	4	5	6	7
I am able to talk about the emotions that a piece of music evokes for me.	1	2	3	4	5	6	7
I don’t spend much of my disposable income on music.	1	2	3	4	5	6	7
I can tell when people sing or play out of tune.	1	2	3	4	5	6	7

When I sing, I have no idea whether I'm in tune or not.	1	2	3	4	5	6	7
Music is kind of an addiction for me – I couldn't live without it.	1	2	3	4	5	6	7
I don't like singing in public because I'm afraid that I would sing the wrong notes.	1	2	3	4	5	6	7
When I hear a piece of music I can usually identify its genre.	1	2	3	4	5	6	7
I would not consider myself a musician.	1	2	3	4	5	6	7
I keep track of new music that I come across (e.g., new artists or recordings).	1	2	3	4	5	6	7

After hearing a new song two or three times, I can usually sing it by myself.	1	2	3	4	5	6	7
I can only need to hear a new tune once and I can sing it back hours later.	1	2	3	4	5	6	7
Music can evoke my memories of past people and places.	1	2	3	4	5	6	7
Please select the most appropriate category:							
I engaged in regular, daily practice of a musical instrument (including voice) for:	0 years	1 year	2 years	3 years	4-5 years	6-9 years	10 or more years

At the peak of my interest I practiced ____ per day on my primary instruments.	0 hours	Half an hour	1 hour	1 and half hours	2 hours	3-4 hours	5 or more hours
I have attended _____ live music events as an audience member in the past twelve months.	0	1	2	3	4-6	7-10	11 or more
I have had formal training in music theory for:	0 years	Half a year	1 year	2 years	3 years	4-6 years	7 or more years
I have had _____ of formal training on a musical instrument (including voice) during my lifetime.	0 years	Half a year	1 year	2 years	3-5 years	5-9 years	10 or more years
I can play _____ musical instruments.	0	1	2	3	4	5	6 or more
I listen attentively to music for _____ per day.	0-15 minutes	15-30 minutes	30-60 minutes	60-90 minutes	2 hours	2-3 hours	4 or more hours

The instrument I play best

(including voice) is: (free response)

APPENDIX D

THE BUCKNELL AUDITORY IMAGERY SCALE

Vividness (BAIS-V)

The following scale is designed to measure auditory imagery, or the way in which you "think about sounds in your head." For the following items you are asked to do the following: Read the item and consider whether you think of an image of the described sound in your head. Then rate the vividness of your image using the following "Vividness Rating Scale." If no image is generated, give a rating of 1.

Please feel free to use all of the levels in the scale when selecting your ratings.

Vividness Rating Scale

1	2	3	4	5	6	7
No Image Present at all			Fairly Vivid			As Vivid As The Actual Sound

Vividness Rating

1. For the first item, consider the beginning of the song "Happy Birthday."

The sound of a trumpet beginning the piece._____

2. For the next item, consider ordering something over the phone.

The voice of an elderly clerk assisting you._____

3. For the next item, consider being at the beach.

The sound of the waves crashing against nearby rocks. _____

4. For the next item, consider going to a dentist appointment.

The loud sound of the dentist's drill._____

5. For the next item, consider being present at a jazz club.

The sound of a saxophone solo._____

6. For the next item, consider being at a live baseball game.

The cheer of the crowd as a player hits the ball._____

7. For the next item, consider attending a choir rehearsal.

The sound of an all-children's choir singing the first verse of a song. _____

8. For the next item, consider attending an orchestral performance of Beethoven's Fifth.

The sound of the ensemble playing. _____

9. For the next item, consider listening to a rain storm.

The sound of gentle rain. _____

10. For the next item, consider attending classes.

The slow-paced voice of your English teacher._____

11. For the next item, consider seeing a live opera performance.

The voice of an opera singer in the middle of a verse._____

12. For the next item, consider attending a new tap-dance performance.

The sound of tap-shoes on the stage._____

13. For the next item, consider a kindergarten class.

The voice of the teacher reading a story to the children._____

14. For the next item, consider driving in a car.

The sound of an upbeat rock song on the radio._____

Control (BAIS-C)

The following scale is designed to measure auditory imagery, or the way in which you "think about sounds in your head." For the following pairs of items you are asked to do the following: Read the first item (marked "a") and consider whether you think of an

image of the described sound in your head. Then read the second item (marked "b") and consider how easily you could change your image of the first sound to that of the second sound and hold this image. Rate how easily you could make this change using the "Ease of Change Rating Scale." If no images are generated, give a rating of 1. Please read "a" first and "b" second for each pair. It may be necessary to cover up "b" so that you focus first on "a" for each pair.

Please feel free to use all of the levels in the scale when selecting your ratings.

Ease of Change Rating Scale

1	2	3	4	5	6	7
No Image Present at All			Could Change the Image but With Effort			Extremely Easy to Change the Image

Change Rating

1. For the first pair, consider attending a choir rehearsal.

a. The sound of an all-children's choir singing the first verse of a song.

b. An all-adults' choir now sings the second verse of the song. _____

2. For the next pair, consider being present at a jazz club.

a. The sound of a saxophone solo.

b. The saxophone is now accompanied by a piano._____

3. For the next pair, consider listening to a rain storm.

a. The sound of gentle rain.

b. The gentle rain turns into a violent thunderstorm._____

4. For the next pair, consider driving in a car.

a. The sound of an upbeat rock song on the radio.

b. The song is now masked by the sound of the car coming to a screeching halt. _____

5. For the next pair, consider ordering something over the phone.

a. The voice of an elderly clerk assisting you.

b. The elderly clerk leaves and the voice of a younger clerk is now on the line._____

6. For the next pair, consider seeing a live opera performance.

a. The voice of an opera singer in the middle of a verse.

b. The opera singer now reaches the end of the piece and holds the final note. _____

7. For the next pair, consider going to a dentist appointment.

a. The loud sound of the dentist's drill.

b. The drill stops and you can now hear the soothing voice of the receptionist._____

8. For the next pair, consider the beginning of the song "Happy Birthday."

a. The sound of a trumpet beginning the piece.

b. The trumpet stops and a violin continues the piece._____

9. For the next pair, consider attending an orchestral performance of Beethoven's Fifth.

a. The sound of the ensemble playing.

b. The ensemble stops but the sound of a piano solo is present._____

10. For the next pair, consider attending a new tap-dance performance.

a. The sound of tap-shoes on the stage.

b. The sound of the shoes speeds up and gets louder._____

11. For the next pair, consider being at a live baseball game.

a. The cheer of the crowd as a player hits the ball.

b. Now the crowd boos as the fielder catches the ball._____

12. For the next pair, consider a kindergarten class.

a. The voice of the teacher reading a story to the children.

b. The teacher stops reading for a minute to talk to another teacher. _____

13. For the next pair, consider attending classes.

a. The slow-paced voice of your English teacher.

b. The pace of the teacher's voice gets faster at the end of class. _____

14. For the next pair, consider being at the beach.

a. The sound of the waves crashing against nearby rocks.

b. The waves are now drowned out by the loud sound of a boat's horn out at sea. _____

APPENDIX E

THE INVOLUNTARY MUSICAL IMAGERY SCALE

Please rate how often you experience each of the following statements.

1	2	3	4	5
Always	Most of the time	Sometimes	Not very often	Never

1. I try hard to get rid of my earworms.
2. It worries me when I have an earworm stuck in my head.
3. I find my earworms irritating.
4. My earworms agitate me.
5. The experience of my earworms is unpleasant.
6. I wish I could stop my earworms.
7. When I get an earworm I try to block it.
8. The rhythms of my earworms match my movements.
9. The way I move is in sync with my earworms.
10. When I get an earworm I move to the beat of the imagined music.
11. My earworms result from unresolved matters.
12. Personal issues trigger my earworms.
13. The content of my earworms mirrors my state of worry or concern.
14. I find my earworms help me focus on the task that I'm doing.

15. Earworms help me when I'm trying to get things done.

On average, I experience earworms… (*Never, Once a month, Once a week, Several times a week, Several times a day, Almost continuously*).

On average, my earworm (the section of music that is stuck lasts): (*Less than 5 seconds, Between 5 to 10 seconds, Between 10 to 30 seconds, Between 30 to 1 minute, More than 1 minute*).

On average, one earworm episode (a period of time when one particular tune gets stuck) lasts: (*Less than 10 minutes, Between 10 minutes and half an hour, Between half an hour and 1 hour, Between 1 and 3 hours, Longer than 3 hours*).

APPENDIX F

MUSICAL IMAGERY SURVEY

Right now, are you hearing music in your head? (Yes or No)

- IF YES: Branch to inner music items.
- IF NO: Branch to cognition items

Inner Music Branch

Affective Valence

(Rated from 1 – Strongly Disagree to 7 – Strongly Agree)

I enjoy hearing the music in my mind.

I would rather not have music in my head right now.

Repetitiveness

Is the music playing over and over in a loop? (Yes or No)

Vividness

(Rate from 1 – Strongly Disagree to 7 – Strongly Agree)

The music in my mind is lifelike.

It feels like I'm actually listening to the song.

My body is responding to the music (feet tapping, head and body moving).

Mental Control

I made the music in my mind start playing on purpose.

I intended to start hearing this music in my mind.

I could make the music in my head stop if I wanted to.

I'm trying to keep the music in my mind playing.

I feel the music playing in my mind is under my control.

Length

How long has the music been playing in your mind? Less than 1 minute; Between 1 to 5 minutes; Between 5 to 30 minutes; Longer than 30 minutes.

How long is the piece of music in your mind? Less than 5 seconds; Between 5 and 10 seconds; Between 10 and 30 seconds; Between 30 seconds and 1 minute; More than 1 minute.

(Rate from 1 – Strongly Disagree to 7 – Strongly Agree)

The music in my mind is something I'm composing or making up myself.

The music in my mind is something I'm rehearsing or practicing.

The music in my mind is distracting me from other things.

I'm paying close attention to the music in my mind.

- Continue to mood and environment items.

Cognition Branch

(Rate from 1 – Strongly Disagree to 7 – Strongly Agree)

Right now, my thoughts are pleasant.

Right now, my thoughts are strange or unusual.

Right now, my thoughts are clear.

Right now, I can hardly control my thoughts.

Right now, my thoughts are racing.

Right now, I am thinking about a lot of things.

Right now, I am having trouble concentrating.

(Rate from 1 – Strongly Disagree to 7 – Strongly Agree)

I was trying to concentrate on what I was doing.

I was doing this activity successfully.

I like what I'm doing right now.

It takes a lot of mental effort to do this activity.

What I'm doing right now is important.

What I'm doing right now is unusual for me.

What I'm doing right now is mentally challenging.

- Continue to mood and environment items.

Mood and Environment Branch

Is music playing in the environment right now? Yes or No

(Rate from 1 – Strongly Disagree to 7 – Strongly Agree)

Right now, I feel happy.

Right now, I feel relaxed.

Right now, I feel bored.

Right now, I feel sad.

Right now, I feel irritated.

Right now, I feel excited.

Right now, I feel tired.

Right now, my situation is stressful.

Right now, my situation is pleasant.

When I started this survey, I was: alone, by myself; with other people but not interacting with them; interacting with other people.

APPENDIX G

START-OF-DAY SURVEY

Roughly, what time did you wake up today? (Free response)

How many hours did you sleep last night? (Free response)

Overall, how well or poorly did you sleep last night? Rate from 1 (Very poorly) to 7 (Very well)